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INTERNATIONAL JOINT COMMISSION TECHNICAL
ADVISORY BOARD ON AIR POLLUTION. REPORT
ON 1953 ENVIRONMENTAL STUDIES IN THE
DETROIT RIVER AREA

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1 April 1955

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**INTERNATIONAL JOINT COMMISSION
TECHNICAL ADVISORY BOARD
ON AIR POLLUTION**

UNITED STATES SECTION

**REPORT ON
1953 ENVIRONMENTAL STUDIES
IN THE
DETROIT RIVER AREA**

**Prepared by
UNITED STATES SECTION
TECHNICAL ADVISORY BOARD ON AIR POLLUTION**

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PUBLIC HEALTH SERVICE

**ROBERT A. TAFT
SANITARY ENGINEERING CENTER**

CINCINNATI, OHIO

APRIL 1, 1955

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PART IReproduced from
best available copy.INTRODUCTION AND SUMMARY OF ACTIVITIES

This report covers the activities carried out in 1953 and is the third of a series of annual reports presenting the results of environmental air pollution appraisal activities which were in progress on the United States side of the international boundary of the Detroit River.

The first (1951)^{1/} and second (1952)^{2/} reports gave in detail the methods of selecting the air sampling stations, a description of sampling equipment, the laboratory techniques employed, and the historical developments of the study. As these reports were distributed to all those interested in the investigation, it was decided that it was unnecessary to repeat those sections in this report.

To review the progress of the various facets of the study, a resume of the work performed in 1953 under each of the five objectives set forth by the Technical Advisory Board in the 1951 report mentioned above, is presented in the following paragraphs.

OBJECTIVE NO. 1

Determination of sources, nature and amounts of atmospheric contaminants resulting from combustion of fuels.

During 1953, the major work done under this objective was the activity of the Canadian section of the Technical Advisory Board in studying vessel smoke emissions. The 1953 smoke emission objectives and the vessel performance records are presented in two reports entitled "Vessel Smoke Abatement Activities in the Detroit River Area During Navigation Season, 1953" and "Report on Smoke Performance of Vessels Plying the Detroit River During Navigation Season, 1953".

OBJECTIVE NO. 2

Determination of sources, nature and amounts of atmospheric contaminants resulting from industrial processes.

The work under this objective was delayed because of lack of funds.

OBJECTIVE NO. 3

Determination of effects of meteorological factors on the dissemination and diffusion of atmospheric contaminants.

Considerable effort has been devoted to this objective during 1953. The results of this work are presented in this report.

OBJECTIVE NO. 4

Determination of the effect of the atmospheric contaminants upon (a) health, (b) vegetation, (c) safety, and (d) economy.

A - HEALTH STUDY

1. Engineering Phase - Extensive evaluations of the atmospheric pollution were made in each of the areas under study from a health standpoint to provide correlating data for use in the medical phase of the study. The pollution data is also used for other purposes.

2. Medical Phase - In developing the health study, it should be pointed out that since no techniques or procedures have been firmly established for measuring the possible relationship between air pollution and health, it was decided that the initial phases of the study would make use of multiple methods and measurements. The first approach was through the review of existing health data in the Detroit-Windsor area such as mortality statistics, hospital and medical care records; industrial and school attendance records, communicable disease reports and comparison of these in areas of high and low pollution.

The second was to conduct a sample morbidity survey in the Detroit-Windsor vicinity, selecting areas of high and low pollution and continuing the survey for sufficient time to eliminate chance factors. A selection of seven residential areas was made, based on environmental data and socio-economic factors.

(a) Preliminary Tests of Forms

A preliminary trial was carried out during March and April of 1953. It was undertaken in order to evaluate the forms prepared and in some cases to discover which of two alternative forms was preferred by the enumerators and appeared to elicit the most reliable results with due consideration of time required, clarity, response, etc. During the preliminary test, which lasted about six weeks, the enumerators completed morbidity forms for some 150 families living in areas bordering on the present test areas. These were carefully analyzed for the purposes of discovering which procedures and forms were most effective and for ascertaining weaknesses in the enumerators. As a result, certain forms were eliminated, instruction and training programs were revised, and periodicity of visits was set at two weeks. Sickness calendars were distributed to all families to assist them in keeping records of all sicknesses.

It was agreed that the health study on both sides of the river should be integral parts of one study. The same forms, instructions, and training programs for enumerators were utilized throughout. Some enumerators who participated in the pretest were retained and others were added as required. The training period for the enumerators lasted one week during which time all aspects of the study were thoroughly reviewed. A test was given

to discover the effectiveness of the instruction and it was found that the enumerators had an adequate understanding of their functions.

(b) Administration of the Detroit Portion

For the Detroit portion of the investigation, Dr. J. Molner, Commissioner of Health, City of Detroit, delegated overall direction to Dr. C. P. Anderson, Assistant Commissioner and a member of the Technical Advisory Board. The six enumerators, four non-white and two white, are full-time employees of the Detroit City Health Department. They visit about five hundred families fortnightly. Approximately half of these reside in low and half in high pollution areas. Half of the families in each group are non-white, the other half are white.

(c) Administration of the Windsor Area Portion

In Canada, technical assistance and direction are supplied by the Department of National Health and Welfare, Ottawa, in cooperation with the Provincial Department of Health of Ontario. The provincial aspects of the study are under the direction of Dr. Cunningham, Director of the Ontario Industrial Hygiene Division. The Epidemiology Division of the Department of National Health and Welfare provided general supervision of the project during the first six months under Dr. A. F. W. Peart. Mr. W. L.

Mc Even of that Division maintained the necessary liaison between the Department of National Health and Welfare, the field office, and the Canadian and American Technical Advisory Board branches of the health study. After Dr. Peart's departure in mid 1953, general supervision became the responsibility of Dr. E. A. Watkinson, Chief of the Occupational Health Division of the Department of National Health and Welfare, Canada.

The Dominion Bureau of Statistics, Ottawa, selected the sample of Canadian households. The Research Division of the Department of National Health and Welfare assisted in preparing forms and undertook statistical analyses.

A field supervisor with a full-time secretary was located in Windsor. Under his direction some 18 part-time enumerators visited the families in Windsor, Harrow and Kingsville. Each of the 12 enumerators in the Windsor area make half of their visits in low and half in high pollution areas.

B - VEGETATION STUDY

In 1953, the actual field work of the vegetation study was initiated. The inspection team was composed of representatives from the Department of Botany, University of Michigan; Detroit City Parks Commission; Chief Smoke Inspectors of the Cities of Detroit, Windsor, Ecorse, Trenton and Wyandotte, and the Science Service, Canadian

Department of Agriculture. Their findings are given in Part IV of this report.

C - SAFETY STUDY

Due to lack of funds, no progress was made on this objective during 1953.

D - ECONOMY STUDY

The studies of the effects of air pollution on paints, textiles, building materials and other studies were not pursued in 1953 due to the lack of funds.

OBJECTIVE NO. 5

The determination of controls necessary. (a) Cost, and (b) by whom should cost be borne?

Under the terms of the Reference, this objective applies only to vessels. The Lake Carriers' and Dominion Marine Associations and vessel owners are co-operating in obtaining the information necessary to answer this objective.

PART II

SUMMARY

1. Samples of suspended particulate matter were collected at four stations from July through December. The highest concentration found was 1012 micrograms per cubic meter of air at station 20, in an industrial area. The lowest concentration found was 20 micrograms per cubic meter of air at station 21, in a residential area. The majority of concentrations found ranged between 100 and 300 micrograms per cubic meter of air.

2. Generally, particulate pollution was not as high during the heating season, as it was during the non-heating season.

3. Confirming previous findings, fluctuation in the quantity of particulate pollution varies more widely at a single station than between stations. An important factor in this fluctuation is wind blown surface material.

4. A weather index has been developed which seems to have merit and perhaps with further evaluation and possible refinement could be an additional tool for use in studying atmospheric dispersion conditions in this area.

5. In order to provide continuity to the study of the concentrations of certain elements in suspended particulate matter, spectrographic analyses were made on a few samples. It was found that the concentration of the

elements were generally about the same as they have been in past years.

6. Sulfur dioxide concentrations are generally higher at elevations of 125 feet above ground than at ground level. Evidences of the importance of mixing in the atmosphere and height of emission of pollutants upon the dispersion of pollutants were detected.

7. Concentrations of suspended particulate matter at ground level are generally higher than at 125 feet above ground level but the data available did not indicate that the difference was statistically significant. No considerable difference was found in the concentration of organic particulate matter at the two elevations.

8. Differences exist between the concentration of certain elements in samples collected at ground level compared to those collected 125 feet above ground level.

9. Settled particle collections for the city as a whole have increased during each of the past four years.

10. Sulfur dioxide concentrations vary widely from place to place in the area.

11. Sulfur dioxide concentrations have remained constant over the last 3 years.

12. Ozone concentrations are not nearly as high in Detroit as they are in Los Angeles.

13. An indication that Radon concentrations might be used as an index of the atmosphere's ability to disperse

pollutants was noted.

14. Marked damage to vegetation was found only in close proximity to presumptive sources of large quantities of atmospheric pollutants and was probably related to specific periodic emissions, perhaps of short duration.

15. No clear indication of a background level of pollution in the industrial areas of Detroit sufficient to cause generalized growth repression of vegetation or foliar injury was observed.

16. Observations made thus far do not indicate that prevalent pollutants could be identified by observing characteristic symptoms of pollution damage in plant species.

PART III

RESULTS OF THE 1953 ENVIRONMENTAL INVESTIGATION

GENERALLY

The air sampling equipment and techniques, laboratory procedures employed, and the location of sampling sites used in this years study were essentially the same as those used in the two previous years of work. A detailed description may be found in the reports on environmental findings in the Detroit-Windsor area for 1951^{1/} and 1952^{2/} published by the Technical Advisory Board on air pollution of the International Joint Commission. When any differences existed between this years procedures, equipment and sampling sites and those of previous years, mention of such is made in this report.

SUSPENDED PARTICULATE MATTER

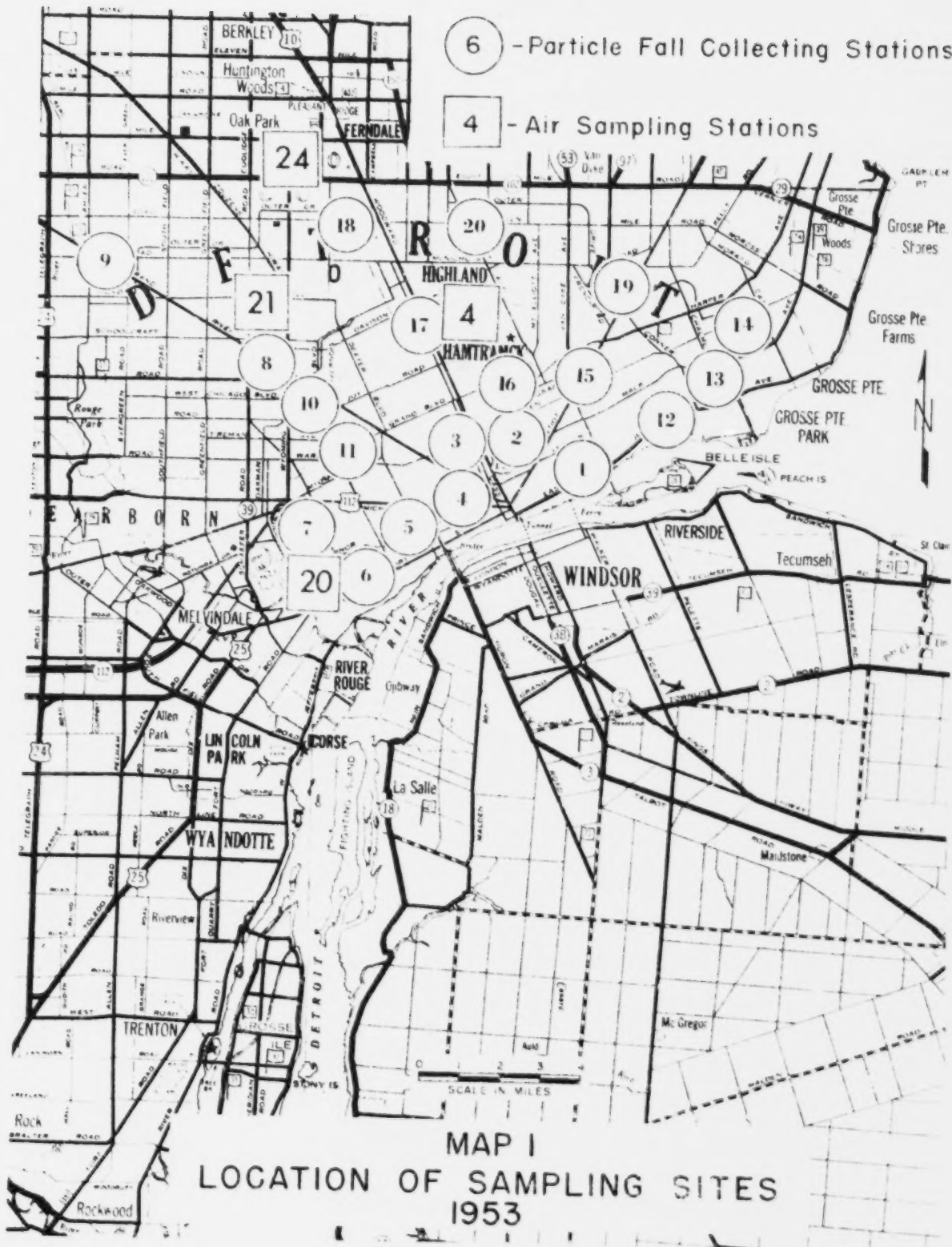
In the 1951 study, samples of suspended particulate matter were collected at thirty one stations in Detroit. In the 1952 study, nine of these locations were again used. In the 1953 study, four of the original stations were selected as sites for the collection of suspended particulate matter to obtain information for use in connection with the health study and for the general evaluation of

this facet of atmospheric pollution. The location of the sampling sites is shown on Map 1.

Figures 1 through 4 present the daily values of particulate matter obtained at stations 4, 20, 21 and 24, using the high volume air sampler with a pleated filter as the collecting medium. It may be noted that occasionally the values on two or more days are the same. This indicates that during these periods, the same filters were used for more than one day and the results averaged. It is realized that this is not the best procedure; however, because of the limited funds available for the study, this was a necessary expedient. At stations 20 and 24 considerable periods were not sampled. These lapses were due in part, to difficulties with the high volume samplers which were corrected by the addition of a suitable rheostat which reduced the speed of the sampler motor and increased the useful life of the sampler several fold. This change reduced the amount of air drawn through a clean pleated filter from about 60 C F M to about 25 C F M.

At station 4 (Figure 1) the fluctuation between the high value of 905 micrograms per cubic meter of air to the low value of 50 micrograms per cubic meter of air was 855 micrograms per cubic meter of air. The majority of concentrations, however, ranged between 100 and 300 micrograms per cubic meter of air. Of special interest is the small fluctuation of the monthly mean. The biggest de-

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crease was from July to August, where a difference of 50 micrograms per cubic meter of air occurred. From July through November, the monthly mean was quite uniform, then increased 33 micrograms per cubic meter of air in December.

These findings would indicate that seasonal variations of the weather as well as variations in human activity cause little demonstrable effect on the atmospheric particulates in this area.

A study of Figure 2 (station 20) shows the maximum value obtained was 1,012 micrograms per cubic meter of air on July 27 and the lowest value of 58 micrograms per cubic meter of air occurred on November 11. The majority of values were in the same range as those at station 4; 100 to 300 micrograms per cubic meter of air. Similarly to station 4, the monthly mean for station 20 decreased in August approximately 70 micrograms per cubic meter of air. From August through October, the monthly mean remained rather uniform. During the beginning of the space heating season, however, the monthly mean, instead of increasing, as might be expected decreased considerably.

There are several possible reasons for the decrease of particulate pollution in the winter months. One was the reduction in industrial and/or construction activity. Another and the most likely, is that during winter months the earth's surface is more likely to be wet or covered with snow, thus reducing the pollution created by wind

blown surface materials.

Data collected at station 21 is shown graphically in figure 3. A comparison of this figure to figures 1 and 2 shows that the concentrations obtained at this station were considerably lower. The lowest value obtained was 20 micrograms per cubic meter of air on December 15 while on July 20 the highest value of 502 micrograms per cubic meter of air was recorded.

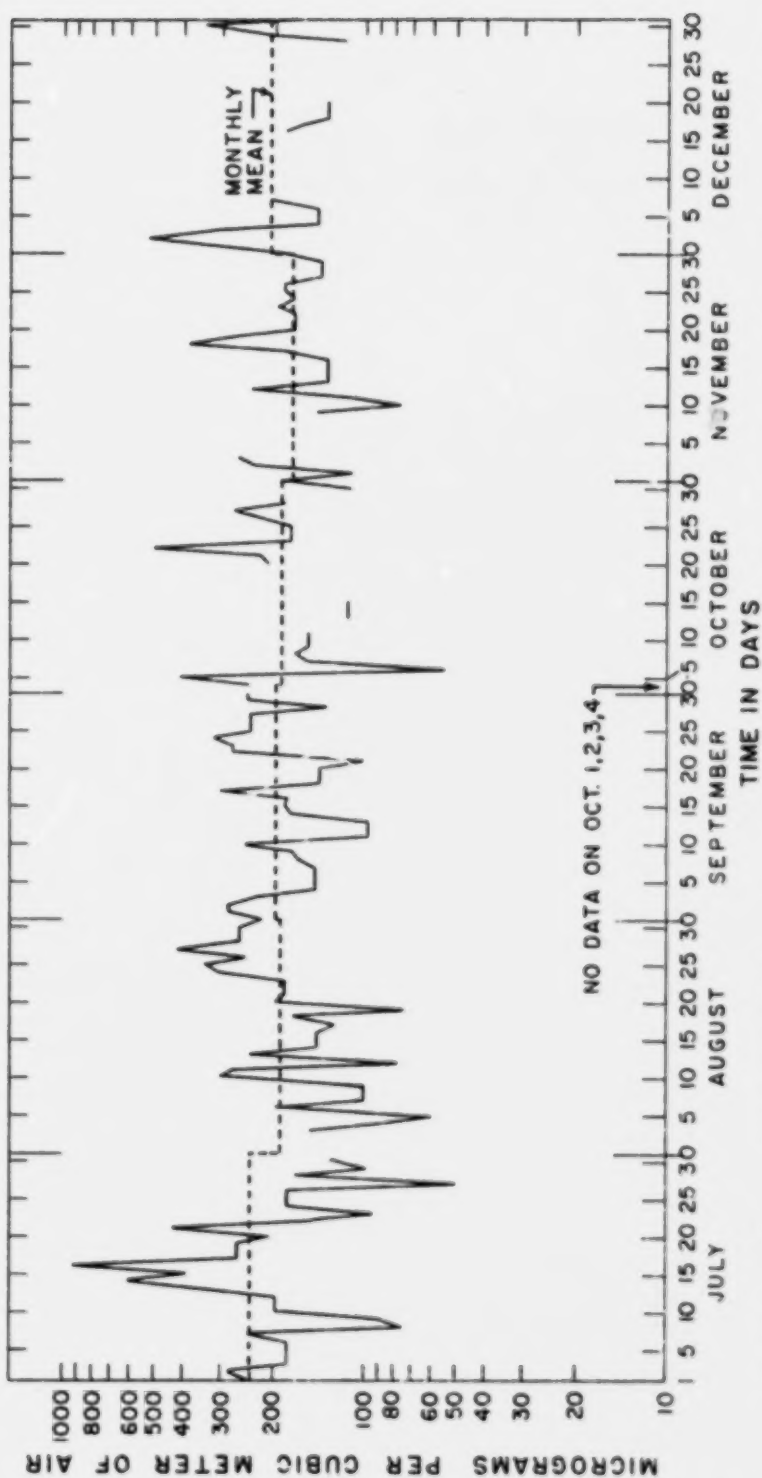
The highest monthly mean at this station occurred in October with an appreciable decrease in November followed by another decrease in December.

The lowest monthly mean for any station and for any month of 80 micrograms per cubic meter of air, was found at this station in December and was less than half that found at stations 4 or 20. Since station 21 is located a considerable distance from any large industrial activity, it is believed that the major reason for the decrease of pollution in this area during the winter months is a decrease in wind blown surface dust.

A study of figure 4, station 24, reveals extremely high particulate pollution when one considers that this area is residential in nature with no large industries located within a radius of several miles. These values were also much higher than had been found in previous years. After the results had been tabulated and these high data noted, an effort was made to determine the cause. It was

found that the sampler had been placed in a location a few blocks from last year's location, where it was subjected to a greater amount of wind blown surface dust than in the previous year. It may be noted that the monthly mean for November was considerably lower than during October and the summer months and decreased even further during the month of December. The reason for the appreciable reduction in particulate pollution during November and December is believed due largely to the snow cover and rain which reduced the amount of wind blown surface dust. It is believed that the experience obtained at this station is of considerable importance, as it proves that wind blown surface dust can have a significant effect on the weight of the samples collected. In other words, nature also contributes to the pollution of an urban atmosphere and not all the atmospheric pollutants arise from industry and from other forms of human activity.

The daily fluctuations of particulate matter at each of the stations is of considerable interest and an effort was made to determine if these changes in concentrations were due to meteorological variations or due to changes in emission rates or even to possible errors in sampling. Therefore, a weather index was developed which could be used to predict the concentrations at a given station. Thus, if the index were accurate, factors other than weather would be the cause for the variations in



STATION #4 - MICROGRAMS OF PARTICULATE MATTER PER CUBIC METER
OF AIR FOR THE PERIOD JULY 1 - DEC. 31, 1953

FIGURE 1

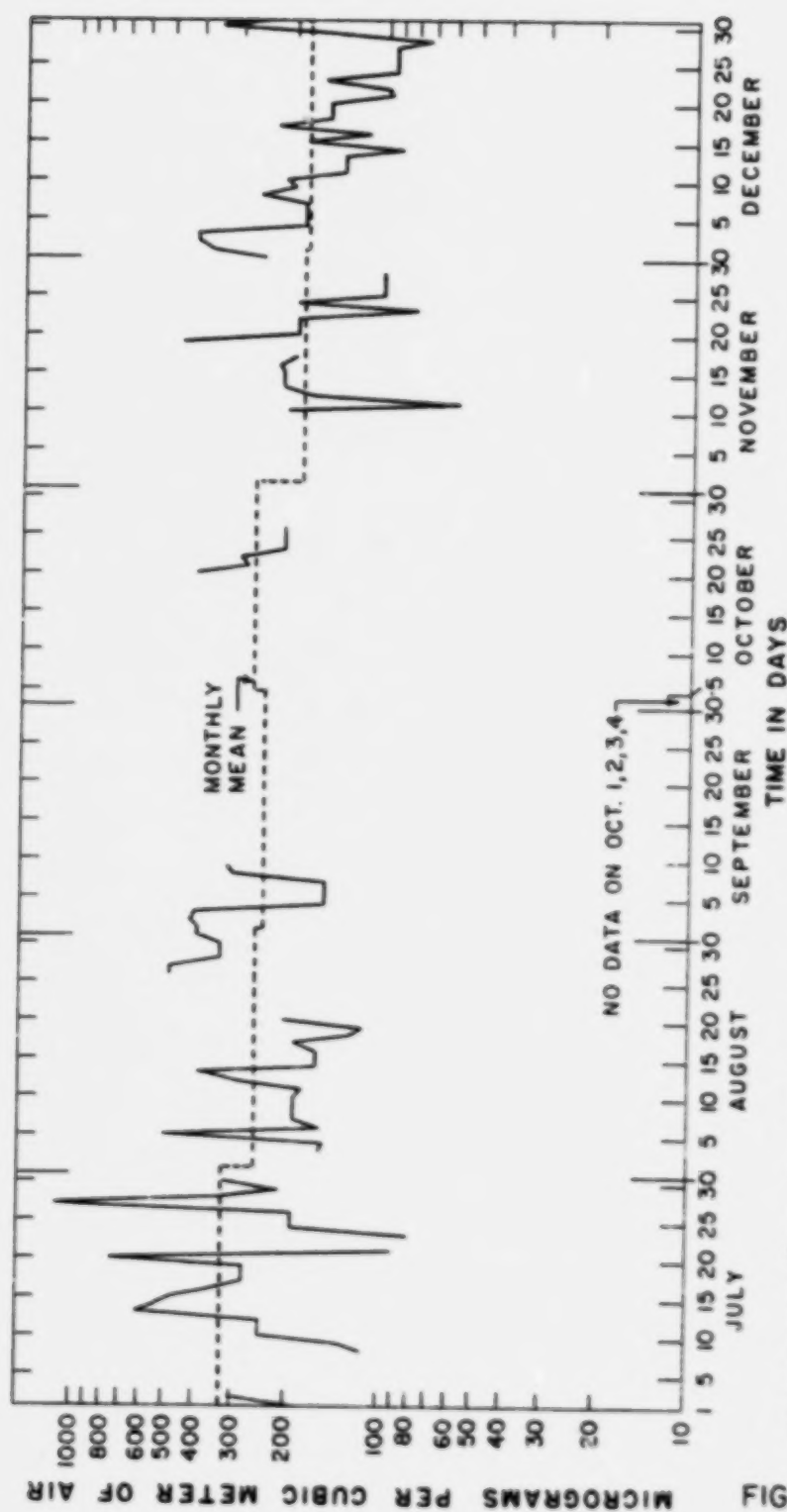
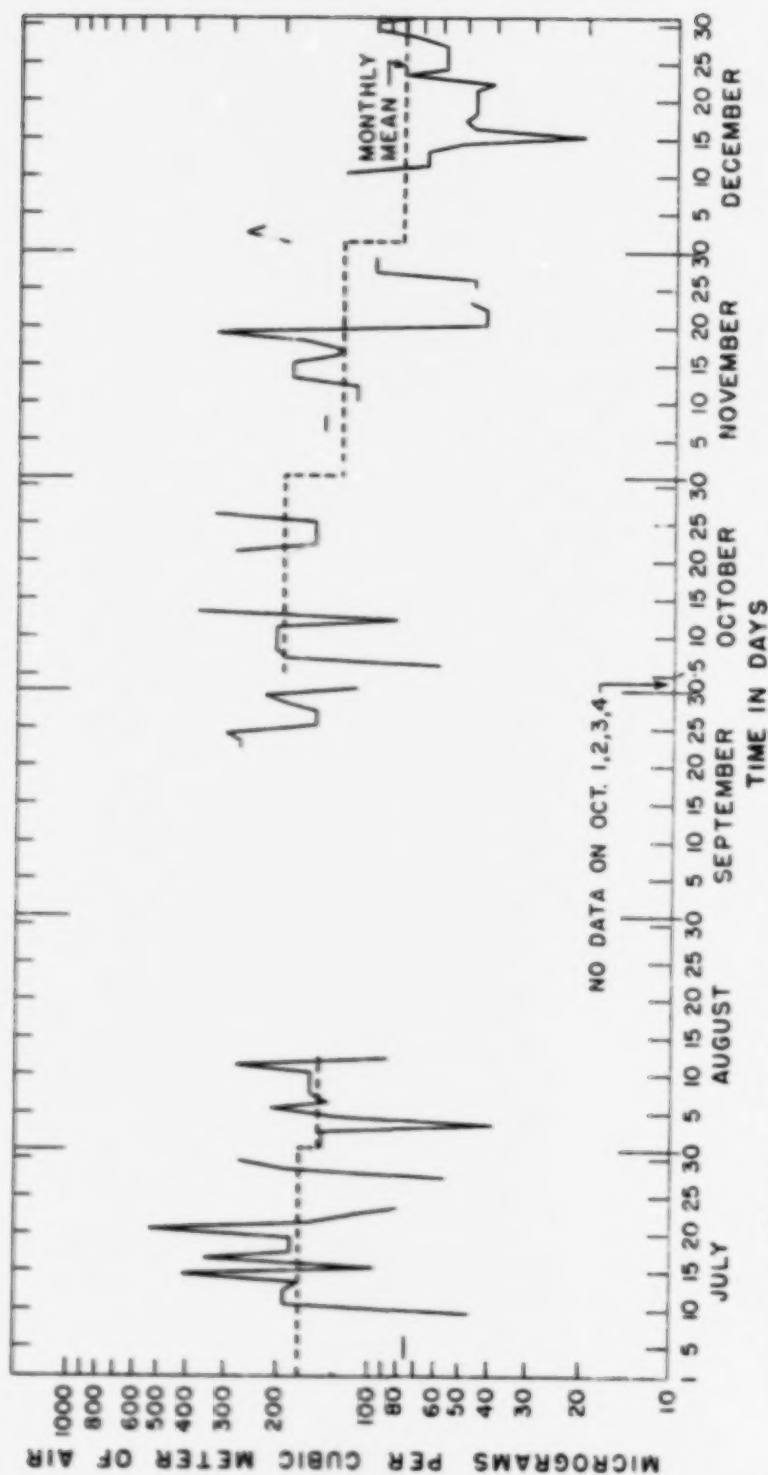


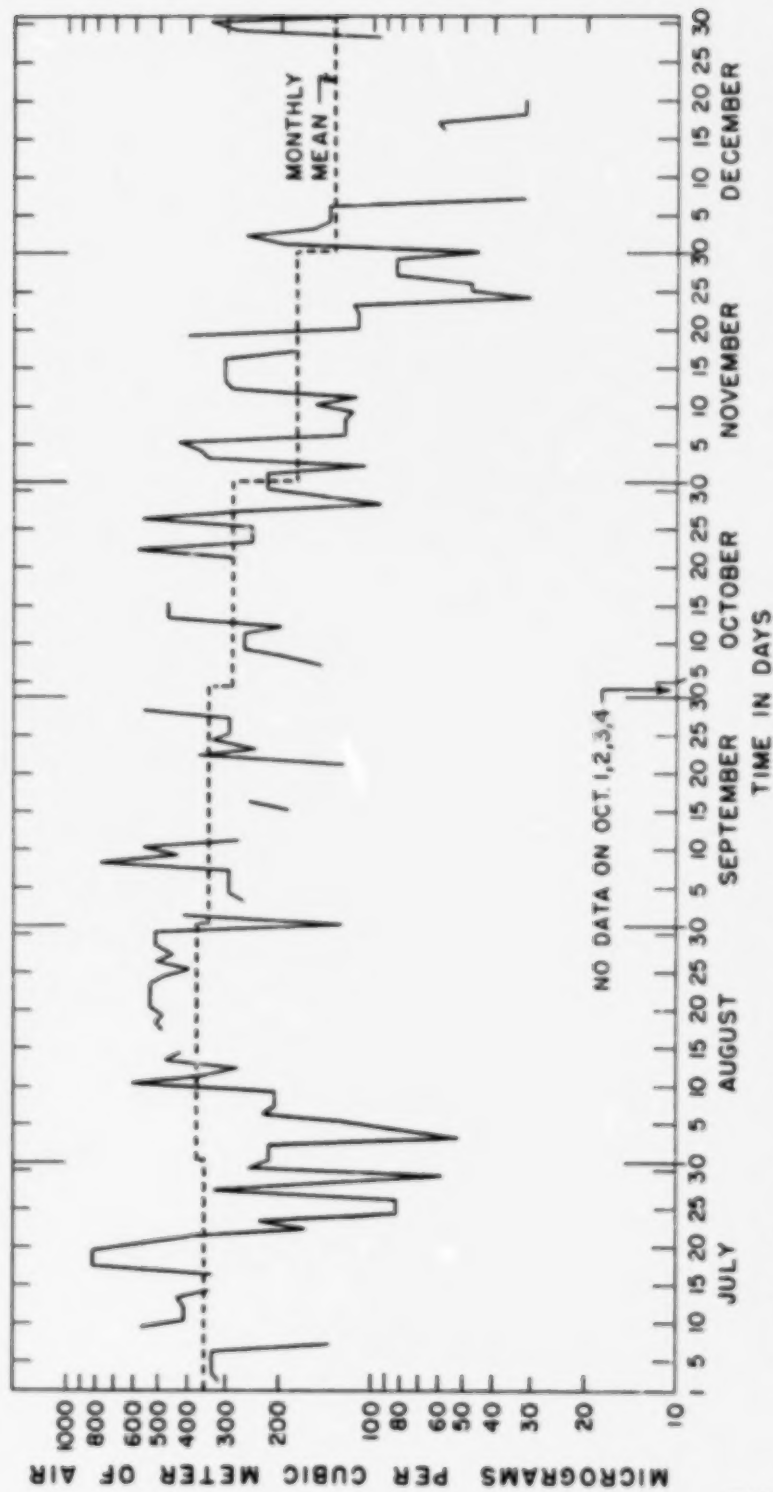
FIGURE 2

STATION #20-MICROGRAMS OF PARTICULATE MATTER PER CUBIC METER
OF AIR FOR THE PERIOD JULY 1 - DEC. 31, 1953



STATION #21 - MICROGRAMS OF PARTICULATE MATTER PER CUBIC METER
OF AIR FOR THE PERIOD JULY 1 - DEC. 31, 1953

FIGURE 3



STATION #24-MICROGRAMS OF PARTICULATE MATTER PER CUBIC METER
OF AIR FOR THE PERIOD JULY 1 - DEC. 31, 1953

FIGURE 4

pollution found. Baynton^{3/} has studied the various meteorological factors which may influence atmospheric pollution in the Detroit River area. He found that changes in wind speed account for about 60 per cent of the observed variance of particulate pollution. A thermal factor consisting of the temperature anomaly and the 24-hour temperature change accounts for a further 20 per cent of the observed variance. Precipitation, as expressed by its duration, accounts for a further, as yet undetermined portion of the observed variance. On applying these factors to independent measurements of pollution, good confirmation was obtained in all seasons except spring.

Baynton expressed the correlation by means of three curves, one for each of the factors described in the above paragraph. The first curve, relating pollution to wind speed, uses pollution units of micrograms per cubic meter, while the other two curves indicate the percentage to be added to, or subtracted from the value obtained from the first curve.

It was recognized that the mean concentration of particulate pollution on any day for an area in general is related to the number and location of sampling sites (among other factors). Inasmuch as only four sampling stations were operated in 1953 as compared to the nine used in the 1952 survey, when Baynton developed his relationships, there was a need of expressing the relationship between

weather and pollution in more general terms.

It was therefore felt desirable to convert the scale of micrograms per cubic meter on the curve relating wind speed and pollution to absolute units. This was done in the following way. The mean wind speed for Detroit based on 72 years of records is 10.6 miles per hour. From the 1952 survey, the particulate pollution equivalent to a wind speed of 10.6 miles per hour was 170 micrograms per cubic meter. This value, which may be considered normal, was arbitrarily designated 100 per cent and particulate pollution concentrations at all other wind speeds were shown as a percentage of that occurring at the mean wind speed of 10.6 miles per hour. Applying the new scale, a complete calm would give particulate pollution equal to 260 per cent of normal whereas a 25 mile per hour wind would give 75 per cent.

Table I is a summary of the pertinent information abstracted from Baynton's three curves and in the form which may be used to give a weather index. The method of computing the index is illustrated by the following example. On a particular day the mean wind speed was 5 miles per hour with a pollution factor of 135. Normal temperature for the day was 28 degrees F., but a mean temperature of 35 was observed and this represented a rise of 10 degrees in 24 hours. The thermal factor was therefore (-7) plus (+10) or (+17) degrees indicating a pollution factor of

Table 1 - Values Abstracted from Curves Correlating Weather and Particulate Pollution

Wind Speed		Thermal Factor		Duration of Precipitation	
Mi/hr	Percent	Deg. F.	Percent	Hours	Percent
0	260	-40	-29	1	-4
1	220	-38	-29	2	-8
2	190	-37	-28	3	-12
3	170	-34	-28	4	-16
4	150	-33	-27	5	-20
5	135	-30	-27	6	-24
6	125	-29	-26	7	-27
7	120	-26	-26	8	-30
8	110	-25	-25	9	-32
9	105	-23	-25	10	-33
10	105	-22	-24	11	-34
11	100	-20	-24	12	-35
12	95	-19	-23	13	-36
13	90	-18	-23	14	-37
14	85	-17	-22	15	-38
15	80	-16	-22	16	-39
16	80	-15	-21	17	-40
17	75	-14	-21	18	-41
18	75	-13	-20	19	-42
19	75	-12	-19	20	-43
20	75	-11	-18	21	-44
21	75	-10	-18	22	-45
22	75	-9	-17	23	-46
23	75	-8	-16	24	-47
24	70				
25	70				

Thereafter 2 percent
per degree F.

(+34) percent. Rain was reported during 6 hours of the day indicating a pollution factor of (-24) percent. Performing the sequence of operations would yield an index of $135 \times (100 + 34 - 24) / 100$ or 148 percent of normal pollution.

Beginning with August 13, 1953, the data required to compute the daily index were logged, and the indices have been computed for the period August 13, to December 31, 1953.

In other sections of this report, the index will be used in ways which will indicate both its reliability and its usefulness in interpreting other data.

To further study the daily results obtained at the four sampling stations, those days when the atmosphere was exceptionally clean and those days when the atmosphere was exceptionally dirty were selected. Those days when the weights of the samples were less than 100 micrograms per cubic meter of air were classified as exceptionally clean and those days when the weights of the samples were more than 400 micrograms per cubic meter of air as exceptionally dirty. Tables 2 and 3 present these data. A study of table 2 reveals that at no time during the six months period did all the stations have values less than 100 micrograms per cubic meter of air although it may be observed that on July 23 and December 28, three of the sampling stations reported less than 100 micrograms per cubic meter of air. The lack of samples at some stations makes it difficult to statis-

tically compare the stations. However, the data shows that station 4 had 14 days when the values were less than 100 micrograms per cubic meter of air whereas station 20 had 11, station 21 had 43 and station 24 had 21 days. The data presented also shows stations 21 and 24 were exceptionally low from November 23 through December 31, 1953.

A comparison of table 2 to table 3 reveals that on July 9, 15, 21 August 5 and 19, some stations recorded more than 400 micrograms per cubic meter of air, whereas on these same days other stations recorded less than 100 micrograms per cubic meter of air.

Table 3 shows that station 24 had the largest number of days with values over 400 micrograms per cubic meter of air. As was explained earlier in the report, this was probably due to a considerable amount of pollution from wind blown surface dust.

On July 20 and on August 27, three of the stations reported high values. On July 14, August 26 and October 22 and December 2, two of the stations report high results.

To examine those days which had two or more stations with either high or low values, a meteorological study was made.

The occurrence of high pollution on July 14 was probably induced by the light winds, which averaged only 5 miles per hour. The weather index suggested that pollution should be about 30 percent above normal.

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TABLE 2 - SAMPLES OF AIR BORNE PARTICULATES WEIGHING
LESS THAN 100 MICROGRAMS PER CUBIC METER OF
AIR BY DATE AND STATION.

Date	Station			
	4	20	21	24
July 3	- 3/	No 1/	73	-
4	-	No	73	-
5	-	No	73	-
6	- 2/	No	73	-
8	75	-	NO	No
9	90	-	45	-
15	-	-	94	No
21	-	90	-	-
23	95	83	79	-
24	-	-	No	83
25	-	-	No	83
26	-	-	No	83
27	52	-	55	-
29	97	-	-	59
Aug. 3	-	-	38	52
4	86	-	-	80
5	63	-	-	-
12	78	-	86	-
19	74	-	No	-
Sept. 11	99	No	No	-
12	99	No	No	No
13	99	No	No	No
Oct. 6	55	No	59	No
12	No.	No	82	-
28	-	No	No	95
Nov. 10	77	-	-	-
11	-	59	-	-
20	-	-	42	-
21	-	-	42	-
22	-	-	42	-

Date	Station			
	4	20	21	24
Nov. 23	-	81	48	-
24	-	-	No	30
25	-	-	46	47
26	-	-	46	47
27	-	-	98	83
28	-	-	98	83
29	-	No	98	83
30	-	-	No	45
Dec. 7	-	-	28	33
11	No	-	67	No
12	No	-	67	No
13	No	-	67	No
14	No	91	51	No
15	No	-	20	No
16	-	-	47	58
17	-	-	60	61
18	-	-	46	33
19	-	-	46	33
20	-	-	46	33
21	No	98	46	No
22	No	-	40	No
23	No	-	71	No
24	No	95	58	No
25	No	95	58	No
26	No	95	58	No
27	No	95	58	No
28	-	74	72	94
29	-	-	98	-
30	-	-	98	-
31	-	-	74	-

1/ - Sample not available.

2/ - Micrograms per cubic meter of air.

3/ - Sample higher than 100 micrograms per cubic meter of air.

TABLE 3 - SAMPLES OF AIR BORNE PARTICULATES WEIGHING 400 AND MORE MICROGRAMS PER CUBIC METER OF AIR BY DATE AND STATION.

Date	Station			Date	Station		
	4	20	21		4	20	24
July 9	-	-	-	Aug. 24	-	No	488
10	-	-	-	26	-	486	506
11	-	-	-	27	415	483	448
12	-	-	-	28	-	-	508
13	-	602	-	29	-	-	508
14	600	533	-	30	-	-	508
15	-	460	-	Sept. 1	-	-	413
16	906	-	-	2	-	413	No
17	-	-	-	3	-	407	No
18	-	-	-	8	-	-	761
19	-	-	-	9	-	-	438
20	-	742	510	10	-	No	561
21	424	-	-	28	-	No	554
27	-	1182	-	Oct. 5	414	No	-
Aug. 5	-	501	-	13	-	No	466
10	-	-	-	14	-	No	466
13	-	-	No	15	-	No	466
14	-	-	No	20	-	No	No
17	-	-	No	22	500	408	589
18	-	-	No	26	-	-	582
19	-	-	No	5	No	No	425
20	-	-	No	19	-	464	400
21	-	-	No	2	520	415	-
22	-	-	No	3	-	415	-
23	-	No	No				

1/ Micrograms per cubic meter of air.

2/ Sample not available.

3/ Sample less than 400 micrograms per cubic meter of air.

On July 20, light winds of 5 miles per hour supported by temperatures 6 degrees above normal favored high pollution. The weather index indicated that pollution should be about 30 percent above normal.

Moderately light winds and temperatures 12 degrees above normal promoted high pollution on August 26 and 27. The weather index for those two days suggested that pollution would be 70 and 55 percent above normal, respectively.

On October 22, the influence of light winds was somewhat modified by a slight drop in temperature. However, the weather index indicated that pollution should be about 20 percent above normal.

On December 2, winds were above average, but the rapid onset of unseasonably mild weather led to poor diffusion conditions and high pollution. The weather index indicated that pollution should be about 35 percent above normal.

In discussing the occurrence of pollution values less than 100 micrograms per cubic meter, special significance can be attached to those days on which either of the high pollution areas, stations 4 and 20, were less than 100. Conversely, the occurrence of values less than 100 in the clean areas, 21 and 24, is not as significant. This is particularly true in late November and December when the continuously damp conditions of the ground led to a

considerable reduction of the wind blown surface dust component. The discussion that follows pertains to those days on which at least two areas recorded pollution less than 100 micrograms per cubic meter of air.

On both July 9 and 23, winds were above normal, and the occurrence of below normal temperatures was especially favorable to good diffusion. The weather index suggested that pollution should be 15 percent less than normal. The prevalence of northwesterly winds on both days contributed further to the low levels of pollution, since all of the stations, in the analysis of wind direction and its influence, showed below average pollution with northwest winds.

There is little evidence, weatherwise, to suggest that pollution should have been low on July 27. Actually, the index implied average diffusion conditions and hence average pollution.

On July 29, rain fell during 12 hours contributing to the low levels of pollution measured. Pollution about 30 percent below normal was suggested by the weather index.

On August 3 and 4, rainfall of 5 and 8 hours duration, respectively was again the factor favoring low pollution. On August 3, the 5 hours of rain was enough to lower the measured pollution in the clean areas, stations 21 and 24 below 100 micrograms per cubic meter, but the two high pollution areas recorded about 150 micrograms per cubic

meter. The index indicated that pollution should be about 15 percent below normal. On August 4, the 8 hours of rainfall was accompanied by falling temperatures. The index indicated a pollution value of 22 percent below normal and low pollution was recorded at stations 4 and 24.

On October 6, strong winds coupled with the onset of unseasonably cold weather resulted in very good diffusion, and low pollution at stations 4 and 21. The weather index suggested that pollution should be about 40 percent below normal.

On November 23, stations 20 and 21 recorded pollution less than 100 micrograms per cubic meter. Strong winds and three hours of rainfall overcame the influence of unseasonable warmth and promoted low levels of pollution. The index suggested that pollution should be reduced to about 80 percent of normal.

The weather of December 28, characterized by average winds, above normal temperatures, and no precipitation, cannot account for the generally low pollution recorded. As a matter of fact, the index suggests that pollution should have been about 10 percent higher than normal.

This limited application of this weather index indicates that it has merit and perhaps with further evaluation, and possibly refinement, could be developed into an additional tool for use in studying air pollution situations

in this area.

Table 4 presents the distribution frequency of total weights of atmospheric samples collected at four stations in Detroit.

The total number of samples at the four stations ranged from 98 at station 24 and 66 at station 21.

Table 5 shows the frequency distribution in percentage of the total weight of air samples by station. At station 4, 89.0 percent of the samples were recorded in the range of 50.1 to 350.0 micrograms per cubic meter of air. At station 20, 75.6 percent were within that range, with none of the samples in the range 0.0 to 50.0 micrograms per cubic meter of air. At station 24, 68.5 percent of the samples were found in the range of 0- to 200.0 micrograms per cubic meter of air. From these data it may be concluded that station 24 had the highest pollution with stations 21 and 4 being ranked as second and third with station 21 being considerably cleaner than the others.

A comparison was made of the data obtained at station 4 for the years 1951, 1952 and 1953. It would have been desirable to make this comparison with other stations; however, this could not be done since, with the exception of station 24, the other stations were not sampled in 1952. Station 24 was omitted from this table for reasons mentioned earlier in this report. Table 6 presents this comparison. It may be seen that station 4 exhibited consid-

TABLE 4 - DISTRIBUTION FREQUENCY OF TOTAL WEIGHTS
OF AIR SAMPLES COLLECTED AT FOUR SAMPL-
ING STATIONS IN THE DETROIT AREA DURING
JULY 1 THROUGH DECEMBER 31, 1953.

July 1 through December 31, 1953				
Weights ¹ / _—	Sampling Stations			
	4	20	21	24
0.0 - 50.0	-	-	12	5
50.1 - 100.0	12	7	15	8
100.1 - 150.0	5	10	10	15
150.1 - 200.0	30	20	13	10
200.1 - 250.0	17	10	4	8
250.1 - 300.0	9	7	6	12
300.1 - 350.0	8	5	3	9
350.1 - 400.0	3	6	2	6
400.1 - 450.0	3	4	-	7
450.1 - 500.0	1	4	-	5
500.1 - 550.0	1	2	1	5
550.1 - 600.0	1	-	-	5
600.1 - 650.0	-	1	-	1
650.1 - 700.0	-	-	-	-
700.1 - 750.0	-	1	-	-
750.1 - 800.0	-	-	-	1
800.1 - 850.0	-	-	-	1
850.1 - 900.0	-	-	-	-
900.1 - 950.0	1	-	-	-
950.1 - 1000.0	-	-	-	-
1000.1 - 15000.0	-	1	-	-
Total Number of Samples	91	78	66	98

¹/_— Weights expressed in micrograms per cubic meter of air.

TABLE 5 - DISTRIBUTION FREQUENCY IN PERCENTAGE
OF TOTAL WEIGHTS OF AIR SAMPLES COL-
LECTED AT 4 SAMPLING STATIONS IN THE
DETROIT AREA JULY 1 - DECEMBER 31, 1953.

Weights ^{1/}	Sampling Station			
	4	20	21	24
0.0 - 50.0	-	-	18.2	5.1
50.1 - 100.0	13.2	9.0	22.7	8.2
100.1 - 150.0	5.5	12.8	15.2	15.4
150.1 - 200.0	33.0	25.6	19.7	10.2
200.1 - 250.0	18.7	12.8	6.1	8.2
250.1 - 300.0	9.8	9.0	9.1	12.2
300.1 - 350.0	8.8	6.4	4.5	9.2
350.1 - 400.0	3.3	7.7	3.0	6.1
400.1 - 450.0	3.3	5.1	-	7.1
450.1 - 500.0	1.1	5.1	-	5.1
500.1 - 550.0	1.1	2.6	1.5	5.1
550.1 - 600.0	1.1	-	-	5.1
600.1 - 650.0	-	1.3	-	1.0
650.1 - 700.0	-	-	-	-
700.1 - 750.0	-	1.3	-	-
750.1 - 800.0	-	-	-	1.0
800.1 - 850.0	-	-	-	1.0
850.1 - 900.0	-	-	-	-
900.1 - 950.0	1.1	-	-	-
950.1 - 1000.0	-	-	-	-
1000.1 - 1500.0	-	1.3	-	-

^{1/} Weights expressed in micrograms per cubic meter of air.

erable improvement in 1953, with 96.6 percent of the samples in the range of 0 to 300 micrograms per cubic meter of air, whereas in 1952, 33.2 percent of the samples were within the range of 150.1 to 300.0 micrograms per cubic meter of air and none of the samples were in the range of 0.0 to 150.0 micrograms per cubic meter of air.

This considerable improvement in airborne solids in this area may be due in part to improved control equipment. However, the main reason for the improvement is believed due to the curtailment of industrial activity during the last half of 1953.

In general, other meteorological factors remaining constant, the intensity of pollution at a point will vary with wind direction, due to differences in sources of pollution located in the various directions. The variations will be small for stations in the center of a homogeneous area and large for perimeter stations. As a result, when we apply the weather index to individual stations, we notice many days of poor correlation, although there is still evident correlation when we consider only the extremes of the index.

A method was devised for estimating the influence of wind direction on the individual stations. The method involves the computed weather index, the measured particulate pollution, and the prevailing surface wind direction for each day. Details of the method are given below.

TABLE 6 - DISTRIBUTION FREQUENCY OF TOTAL WEIGHTS OF AIR SAMPLES
COLLECTED AT STATION 4 DURING 1951, 1952 and 1953.

Weights ^{1/}	August 7 through Sept. 19				May 7 through	
	1953		1952		June 17, 1951	
	Number	Percent	Number	Percent	Number	Percent
0.0 - 50.0	3	10.4	-	-	-	-
50.1 - 100.0	5	17.2	-	-	-	-
100.1 - 150.0	8	27.6	-	-	1	2.3
150.1 - 200.0	5	17.2	4	19.0	3	7.3
200.1 - 250.0	3	10.4	2	9.4	8	19.5
250.1 - 300.0	4	13.8	1	4.8	4	9.8
300.1 - 350.0	-	-	3	14.3	53	12.2
350.1 - 400.0	1	3.4	3	14.3	3	7.3
400.1 - 450.0	-	-	3	14.3	7	17.2
450.1 - 500.0	-	-	3	14.3	1	2.4
500.1 - 550.0	-	-	1	4.8	3	7.3
550.1 - 600.0	-	-	1	4.8	3	7.3
600.1 - 650.0	-	-	-	-	1	2.4
650.1 - 700.0	-	-	-	-	-	-
700.1 - 750.0	-	-	-	-	2	4.9
750.1 - 800.0	-	-	-	-	-	-
Total Number of Samples	29	29	21	21	41	41

^{1/} Weights expressed in micrograms per cubic meter of air.

Consider a series of days all having prevailing winds from the north. For each day, the observed pollution and the computed index enable us to estimate what the pollution would be for an average day, that is for a day with mean wind speed 10.6 miles per hour, a normal and steady temperature, and no precipitation. We get a series of estimates of the particulate pollution during northerly winds and weather index of 100 percent. The mean of the series is used as the degree of pollution, typical of northerly winds under average weather conditions.

As an example of the type of computation involved, suppose the measured pollution was 70 micrograms per cubic meter and the weather index was 50 percent. Then the pollution under average conditions (100 percent weather index) would be 140 micrograms per cubic meter. On a second day the measured pollution might be 190 micrograms per cubic meter of air and the weather index might be 138 percent. Then the pollution under average conditions is estimated to be 130 micrograms per cubic meter. If these were the only examples with northerly winds, the mean for northerly winds would be 135 micrograms per cubic meter.

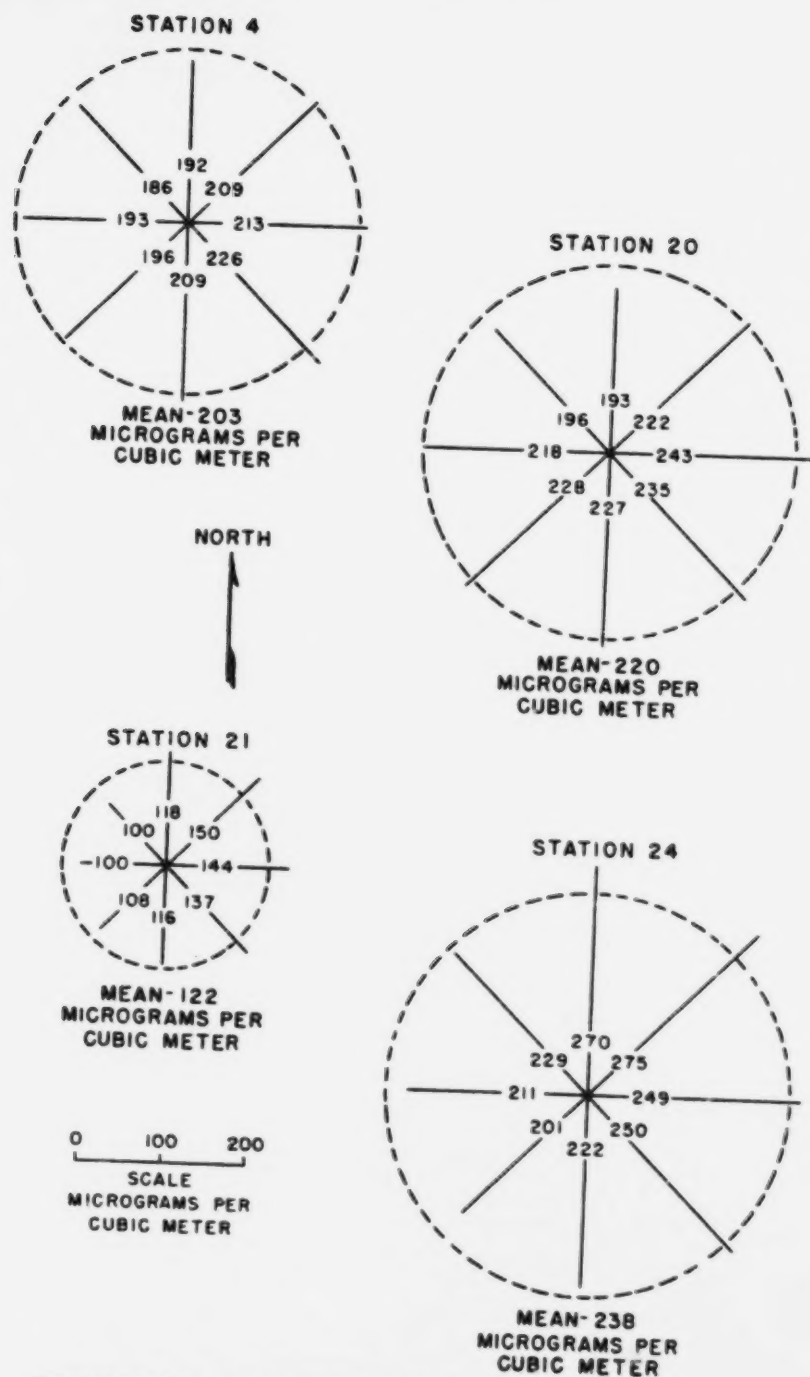
In making computations for a single station, an estimate of the pollution under average conditions is made for each day, and the estimate is assigned to the appropriate prevailing wind classification. As might be expected, many estimates are obtained for the more frequent

wind directions, whereas for some wind directions hardly enough estimates were obtained to permit reliable results.

To overcome these difficulties, a longer series of data than was supplied in 1953 alone was used. Having in mind that the weather index was found to be quite unreliable for the spring months, the analysis was applied to all available data for the period August 1953 to February 1954 and June to October 1954. In addition, the values for each wind direction were smoothed by the method of overlapping means. Although there were still regrettably few instances of prevailing winds from the east and southeast, the resultant patterns obtained appear reasonable in the light of field knowledge of the areas surrounding the stations.

The results are summarized in a series of wind roses. (Fig. 5) The line drawn to the north represents the pollution typical of northerly winds under average diffusion conditions; that drawn to the east represents the pollution typical of easterly winds under average diffusion conditions and so on.

It must be remembered that this shows the influence of wind direction alone on pollution. It does not represent the average pollution that will be experienced under each of the wind directions, since, in nature other weather factors which affect diffusion change also with changing wind direction. The weather index tends to be low with



EXPECTED CONCENTRATION OF AIRBORNE
PARTICULATES WITH VARIOUS WIND DIRECTIONS,
UNDER "WEATHER INDEX" CONDITIONS OF 100 %

FIGURE 5

northwesterly winds because the thermal factor is usually negative, and high with southerly winds because the thermal factor is usually positive.

ELEMENTS

The concentrations of certain elements in airborne particulates and their relationship to each other, to the elements found in the soil, as well as other relationships have been thoroughly discussed in the 1951 and 1952 reports. The results of these studies were such that it was not deemed necessary to expend the monies and efforts necessary to continue, in detail, this line of investigation. However, to provide continuity to this phase of the investigation, certain selected samples were analyzed spectographically.

To obtain the desired information regarding the concentrations of the various elements, five samples per month from each station were selected at random. The contaminants from the selected five samples for a station were removed from the filter medium into a beaker in the manner described by Keenan,^{4/} thus, making a composite sample for the month for the station. The results of the spectrographic examination of these composite samples are presented in table 7.

At station 4 during the month of September, calcium and aluminum concentrations showed appreciable increases over the other months, whereas silicon and iron



TABLE 7 - CONCENTRATIONS, IN MICROGRAMS PER CUBIC METER OF AIR, OF 21 ELEMENTS FOUND AT FOUR STATIONS IN DETROIT, BY MONTH, FOR THE PERIOD AUGUST THROUGH DECEMBER 1953.

STATION 4					
Element	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Calcium	8.98	15.94	7.35	5.77	6.64
Silicon	4.04	4.77	2.21	3.47	3.99
Iron	1.12	1.00	.46	.72	.83
Aluminum	.85	1.26	.92	.55	.63
Titanium	.45	.30	.27	.29	.33
Magnesium	.43	.30	.20	.23	.26
Lead	.223	.399	.275	.143	.083
Tungsten	.13	.08	.07	ND <u>1</u> /	ND <u>1</u> /
Zinc	.11	.08	.09	.14	.16
Copper	.09	.08	.04	.06	.10
Manganese	.07	.06	.06	.06	.07
Molybdenum	.05	.03	.03	.01	.03
Chromium	.03	.02	.01	.01	.02
Tin	.018	.020	.019	.012	.003
Barium	.011	.008	.009	.012	.013
Vanadium	.011	.010	.007	.012	.017
Cadmium	.007	.010	.009	ND <u>1</u> /	ND <u>1</u> /
Antimony	.007	.006	.007	.002	.003
Nickel	.002	.006	.006	.003	.003
Cobalt	.0007	.0006	<.0006	<.0009	.001
Beryllium	ND <u>1</u> /	ND <u>1</u> /	<.0006	ND <u>1</u> /	ND <u>1</u> /

ND 1/ indicates that the analysis lines were not detectable in the one per cent portions of the samples exposed spectrophotically.

TABLE 7 - CONTINUED

STATION 20					
ELEMENT	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Calcium	4.41	1.49	10.83	1.19	3.09
Silicon	1.32	1.81	4.33	1.43	1.23
Aluminum	1.10	.38	1.35	.60	.78
Iron	.84	.75	.90	.60	1.025
Magnesium	.33	.17	.47	.19	.16
Titanium	.22	.15	.03	.24	.41
Lead	.22	.20	.18	.12	.21
Tungsten	.13	.01	.07	.14	.01
Zinc	.11	.07	.07	.09	.08
Copper	.07	.03	.07	.01	.01
Manganese	.07	.05	.05	.05	.06
Molybdenum	.04	.03	.03	.05	.02
Chromium	.02	.03	.03	.19	.02
Tin	.022	.015	.018	.012	.017
Vanadium	.011	.008	.007	.012	.006
Nickel	.009	.005	.006	.002	.002
Antimony	.009	.006	.007	.010	.006
Barium	.009	.006	.009	.002	.008
Cadmium	.007	.008	.009	.012	.006
Cobalt	<.0007	.0005	<.0005	.0007	<.0006
Beryllium	ND	<.0005	ND	ND	<.0006

TABLE 7 - CONTINUED

STATION 21					
ELEMENT	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Calcium	20.44	9.38	11.12	10.02	20.62
Silicon	2.30	4.22	5.00	3.00	1.55
Iron	.64	.59	.53	.63	.64
Aluminum	.64	.89	.53	.94	.64
Titanium	.51	.35	.28	.25	.39
Magnesium	.20	.35	.31	338	.21
Manganese	.05	.09	.08	.038	.052
Tungsten	.05	.05	.04	.10	.10
Copper	.03	.05	.06	.04	.01
Molybdenum	.026	.012	.014	.025	.026
Zinc	.02	.04	.04	.06	.13
Chromium	.013	.009	.014	.019	.013
Barium	.013	.007	.011	.004	.008
Lead	.013	.090	.106	.19	.21
Tin	.013	.012	.011	.010	.021
Vanadium	.008	.007	.008	.006	.010
Cadmium	ND	ND	ND	.004	.008
Antimony	.002	.002	.002	.004	.003
Nickel	.002	.001	.003	.004	.002
Cobalt	<.0008	<.0007	<.0008	.0004	<.0008
Beryllium	ND	ND	ND	ND	ND

27-D

TABLE 7 - CONTINUED

STATION 24					
ELEMENT	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Calcium	13.89	9.01	9.91	10.22	4.86
Silicon	4.17	2.70	4.46	.59	4.37
Aluminum	1.09	3.38	.94	.64	.92
Iron	.87	.43	.62	.64	1.21
Magnesium	.52	.68	.37	.28	.36
Lead	.17	.17	.12	.13	.24
Tungsten	.14	.09	.05	.05	.10
Titanium	.07	.06	.11	.38	.66
Zinc	.07	.06	.09	.06	.19
Copper	.05	.02	.08	.05	.10
Manganese	.053	.045	.100	.038	.074
Molybdenum	.035	.023	.012	.013	.025
Tin	.014	.009	.012	.013	.019
Cadmium	ND	ND	ND	ND	.012
Nickel	.007	.003	.003	.002	.007
Chromium	.007	.005	.010	.010	.019
Vanadium	.007	.006	.010	.010	.012
Cobalt	.0005	.0003	<.0007	<.0008	<.0007
Barium	.002	.001	.003	.013	.011
Antimony	.001	.001	.003	.002	.007
Beryllium	ND	ND	ND	ND	ND

concentrations showed a decrease in October and lead values showed a decrease in December.

At station 20, the calcium and magnesium concentration showed a decrease in September. In November, the iron and lead concentrations were less than the other months. Tungsten was appreciably higher in the months of August and November.

At station 21, the calcium concentration was appreciably higher in September and December. Silicon was higher in October and titanium showed an increase in August.

At station 24, calcium was considerably less in December than during the other months, whereas iron, titanium, zinc and copper concentrations showed a substantial increase during that month.

Table 8 presents the percentages of each element of the sum of the particular twenty-one elements determined at each of the four stations. (This is not the proportion of the total collected sample.) It may be observed that station 21 had a greater percentage of calcium than did the other stations and less silicon and aluminum.

At station 4, calcium and silicon accounted for 81 percent of the sample, at station 20 for 69 percent, station 21 for 87 percent and at station 24 for 79 percent of the sample.

In table 9 are shown the median, minimum and

TABLE 8 - PERCENTAGE OF EACH ELEMENT TO THE SUM OF
21 ELEMENTS FOR AIR BORNE SAMPLES AT FOUR
STATIONS IN DETROIT.

ELEMENTS	STATION			
	4	20	21	24
Calcium	57.65	46.97	71.75	59.07
Silicon	23.91	22.37	16.11	20.09
Aluminum	5.44	9.42	3.65	8.59
Iron	5.34	9.22	3.04	4.65
Titanium	2.12	2.57	1.78	1.58
Magnesium	1.84	2.95	1.45	2.73
Lead	1.45	2.08	.61	1.02
Zinc	.75	.94	.29	.58
Copper	.48	.42	.19	.37
Manganese	.41	.63	.32	.38
Molybdenum	.19	.38	.10	.13
Chromium	.12	.65	.12	.07
Tin	.09	.19	.07	.08
Barium	.07	.08	.04	.04
Vanadium	.07	.10	.04	.06
Nickel	.03	.05	.01	.03
Antimony	.03	.08	.13	.02
Cadmium	tr	.09	tr	tr
Beryllium	tr	tr	tr	tr
Cobalt	tr	tr	tr	tr
Tungsten	tr	.81	.34	.53

maximum values. This table reveals that the range between minimum and maximum for most of the elements was quite large. It should be noted that calcium and silicon were present in greater amounts than the other elements analyzed with the mean values for calcium and silicon appreciably higher than for the other elements.

During the last half of August and the first part of September 1953, meteorological factors were favorable for higher than normal air pollution. During the same period in 1952, similar meteorological conditions also prevailed. For this reason, spectographic analyses of individual samples from three stations, on three different days of relatively high pollution (August 27 and 31; September 3, 1953) were made. These data are presented in table 10. A comparison of these data to those found in 1952 shows that the calcium concentration was higher in 1953. Aluminum showed a minor decrease. Iron, lead and magnesium as well as other elements were found in approximately the same concentrations.

The median, minimum and maximum values were determined for these three days and are tabulated in table 11. A comparison of this table to table 9 which presents the median, minimum and maximum figures for the five months period reveals that the median values for calcium, aluminum, magnesium, iron and manganese were appreciably higher during this period.

FIGURE 9 - MEDIAN, MINIMUM AND MAXIMUM FIGURES FOR 21 ELEMENTS DETERMINED SPECTROGRAPHICALLY FROM SAMPLES COLLECTED AT FOUR STATIONS DURING THE PERIOD AUGUST THROUGH DECEMBER, 1953.

Element	values in micrograms per cubic meter of air		
	Median	Minimum	Maximum
Calcium	9.38	1.19	20.62
Silicon	3.00	.1	5.00
Aluminum	.90	.40	3.40
Iron	.70	.40	1.20
Magnesium	.31	.16	.68
Titanium	.29	.03	.66
Lead	.20	tr	.40
Zinc	.09	.02	.19
Tungsten	.09	abs.	.14
Manganese	.06	.04	.10
Copper	.05	.01	.10
Molybdenum	.03	.01	.05
Chromium	.02	tr	.03
Tin	.01	tr	.02
Vanadium	.01	.006	.017
Barium	.009	.001	.013
Cadmium	.006	Abs.	.012
Beryllium	<.006	Abs.	<.006
Antimony	.004	.001	.010
Nickel	.003	.001	.009
Cobalt	.0007	.0003	.001

TABLE 10 - TOTAL WEIGHT OF SAMPLES AND THE SPECTROGRAPHIC RESULTS, IN MICROGRAMS PER CUBIC METER OF AIR, OBTAINED AT THREE STATIONS ON THREE DIFFERENT DAYS WHEN THE METEOROLOGICAL FACTORS INDICATED HIGHER THAN NORMAL POLLUTION.

STATION	4	4	4	20	20	24	24	24
TOTAL WEIGHT	415	230	220	483	407	397	448	264
DATE	8/27/53	9/3/53	8/31/53	8/27/53	9/3/53	8/31/53	8/27/53	9/3/53
ELEMENTS								
Calcium	34.97	25.27	35.49	11.44	47.73	11.73	17.59	45.21
Aluminum	4.36	3.15	2.25	.35	4.53	4.46	.35	3.44
Iron	4.36	3.15	2.25	.68	2.96	4.46	2.20	2.26
Silicon	2.62	11.36	2.25	.91	7.15	7.01	10.57	2.08
Magnesium	1.92	1.01	.71	.23	.95	1.76	1.67	1.00
Lead	.87	.03	.30	.15	.45	.45	.44	.23
Zinc	.87	.03	.03	.09	.03	.03	.07	.02
Titanium	.44	1.27	.11	.22	.45	.29	.33	.02
Copper	.35	3.15	.12	.05	.18	.12	.13	.36
Manganese	.18	.13	.12	.06	.18	.24	.18	.10
Tungsten	ND 1/	.13	ND	ND	ND	ND	ND	.10
Tin	.09	.05	.04	.004	.06	.06	.04	ND
Barium	.07	.02	.04	.009	.06	.05	.04	.03
Vanadium	.05	.02	.02	.02	.02	.02	.03	.01
Nickel	.03	.01	.009	ND	.03	.009	.01	.01
Antimony	.03	.02	.02	ND	.04	.02	.01	.007
Chromium	.03	3.15	.009	.02	.06	.009	.01	.01
Molybdenum	.02	ND	.01	.01	.02	.02	.01	.01
Cadmium	ND	ND	ND	ND	.01	ND	ND	.01
Cobalt	.005	.003	.003	.004	.004	.004	.003	.003
Beryllium	ND	.13	ND	ND	ND	ND	.003	ND

1/ ND indicates that the analysis lines were not detectable in the one per cent portions of the samples exposed spectrographically.

TABLE 11 - MEDIAN, MINIMUM AND MAXIMUM FIGURES FOR 21 ELEMENTS DETERMINED SPECTROGRAPHICALLY FROM SAMPLES COLLECTED AT THREE STATIONS ON THREE SELECTED DAYS. AUGUST 27, 31 AND SEPTEMBER 3, 1953.

ELEMENT	MEDIAN	MINIMUM	MAXIMUM
Calcium	28.56	11.44	47.73
Aluminum	3.20	.30	4.50
Iron	2.90	.70	4.50
Silicon	2.60	.90	11.40
Magnesium	1.00	.23	1.92
Titanium	.44	.11	1.82
Cadmium	abs.	abs.	.01
Manganese	.18	.06	.24
Copper	.13	.05	.35
Tungsten	abs.	abs.	.13
Tin	.05	tr	.09
Barium	.045	.009	.059
Zinc	.03	.02	.44
Chromium	.02	.01	.06
Vanadium	.018	.014	.053
Antimony	.018	abs.	.036
Cadmium	abs.	abs.	.01
Molybdenum	.01	.01	.02
Nickel	.009	abs.	.030
Beryllium	abs.	abs.	.004
Cobalt	.0004	.0003	.0005

Table 12 presents the percentage frequency distributions and median, minimum and maximum values for 21 elements, analyzed from the composite samples. The significance of the concentrations of these elements, their variations in concentration and their possible relationships with sources of pollution, health aspects, vegetation damage, soiling, visibility reduction, etc., have not been established at this time.

VARIATION WITH ELEVATIONS ABOVE GROUND OF CONCENTRATIONS OF SO_2 , SUSPENDED PARTICULATES, SUSPENDED ORGANIC PARTICULATES AND CERTAIN ELEMENTS IN PARTICULATES.

A study was made to determine the effect of elevation of the sampling point on SO_2 and particulate pollution. For the SO_2 study, two Thomas Autometers were used. One was located in the basement of a building with the sampling probe located about two feet from the ground. The other autometer was located on the tenth floor approximately 125 feet above the ground, with the sampling probe placed through the window. The test was conducted in the heart of the Detroit business district (Majestic Building - Woodward and Michigan) during the month of March.

Two high volume air samplers were used for the collection of particulates. One of these samplers was placed on the tenth floor ledge of the building. The other was

TABLE 12 - PERCENTAGE FREQUENCY DISTRIBUTIONS, MEDIAN, MINIMUM AND MAXIMUM FIGURES FOR 21 ELEMENTS DETERMINED SPECTROGRAPHICALLY (IN MICROGRAMS PER CUBIC METER OF AIR) FOR AIR SAMPLES COLLECTED AT 4 SAMPLING STATIONS IN THE DETROIT AREA AUGUST THROUGH DECEMBER, 1953.

Weight (Micrograms per cubic meter of air)	AIR SAMPLING STATION			
	4	20	21	24
CALCIUM				
0.0 - 5.0	0	80	0	20
5.0 - 10.0	80	0	20	40
>10.0	20	20	80	40
Median	7.3	3.1	11.12	9.9
Minimum	5.8	1.2	9.3	4.9
Maximum	15.9	10.8	20.62	13.9
MAGNESIUM				
0.0 - 0.75	100	100	100	100
0.75 - 1.5	0	0	0	0
>1.5	0	0	0	0
Median	.26	.19	.31	.37
Minimum	.20	.16	.20	.28
Maximum	.43	.47	.38	.68
NICKEL				
0.001 - .010	100	100	100	100
>.011	0	0	0	0
Median	.003	.005	.002	.003
Minimum	.002	.002	.001	.002
Maximum	.006	.009	.004	.007
COPPER				
0.001 - 0.099	80	100	100	80
>.10	20	0	0	20
Median	.08	.03	.04	.05
Minimum	.04	.01	.01	.02
Maximum	.10	.07	.06	.10
ALUMINUM				
0.0 - 2.5	100	100	100	100
2.5 - 5.0	0	0	0	0
>5.0	.06	.05	.05	.05
Median	.06	.05	.04	.04
Minimum	.07	.07	.09	.10
Maximum				
ZINC				
0.0 - 2.5	100	100	100	100
2.5 - 5.0	0	0	0	0
>5.0	0	0	0	0
Median	.11	.08	.04	.07
Minimum	.08	.07	.02	.06
Maximum	.16	.11	.13	.19

TABLE 12 - CONTINUED

Weight (Micro-grams per cubic meter of air.)	AIR SAMPLING STATION			
	4	20	21	24
MOLYBDENUM				
0.001 - 0.020	80	20	40	40
0.020	20	80	60	60
Median	.02	.03	.025	.023
Minimum	.01	.02	.012	.012
Maximum	.03	.05	.026	.035
MANGANESE				
0.001 - 0.200	100	100	100	100
0.200	0	0	0	0
Median	.06	.05	.05	.05
Minimum	.06	.05	.04	.04
Maximum	.07	.07	.09	.10
CHROMIUM				
0.001 - 0.01 $\frac{1}{2}$	40	0	60	80
0.01 $\frac{1}{2}$	60	100	40	20
Median	.02	.03	.013	.010
Minimum	.01	.02	.009	.005
Maximum	.03	.19	.019	.019
IRON				
0.0 - 2.5	100	100	100	100
2.5 - 5.0	0	0	0	0
5.0	0	0	0	0
Median	.83	.84	.63	.64
Minimum	.46	.60	.53	.53
Maximum	1.12	1.03	.64	1.21
ANTIMONY				
0.001 - 0.015	100	100	100	100
0.015	0	0	0	0
Median	.006	.007	.002	.002
Minimum	.002	.006	.002	.001
Maximum	.007	.010	.004	.007
BARIUM				
0.001 - 0.015	100	100	100	100
0.015	0	0	0	0
Median	.011	.008	.008	.003
Minimum	.008	.002	.004	.001
Maximum	.013	.009	.011	.013
TITANIUM				
0.001 - 0.050	100	20	0	00
0.050	100	80	100	100
Median	.30	.22	.35	.11
Minimum	.27	.03	.25	.06
Maximum	.45	.41	.51	.66

TABLE 12 - CONTINUED

Weight (Micro-grams per cubic meter of air.)	AIR SAMPLING STATION			
	4	20	21	24
CADMIUM				
0.001 - 0.005	-	0	20	-
>0.005	60	100	20	20
Median	.007	.008	abs.	abs.
Minimum	abs.	.006	abs.	abs.
Maximum	.010	.012	.008	.012
BERYLLIUM				
Per cent present	20	40	zero	-
Median	abs.	abs.	abs.	-
Minimum	abs.	abs.	abs.	-
Maximum	<.0006	<.0006	abs.	-
VANADIUM				
0.001 - 0.010	40	60	100	80
>0.010	60	40	0	20
Median	.011	.008	.008	.010
Minimum	.007	.006	.006	.006
Maximum	.017	.012	.010	.012
TUNGSTEN				
0.001 - 0.020	60	40	0	0
>0.020	.07	60	100	100
Median	abs.	.07	.05	.09
Minimum		.01	.04	.05
Maximum		.14	.10	.14
COBALT				
Per cent present	100	100	100	100
Median	.006	<.0007	<.0008	<.0007
Minimum	<.0006	<.0005	.0004	.0003
Maximum	.001	.0007	<.0008	<.0008
LEAD				
0.0 - 0.5	100	100	100	100
0.5 - 1.0	0	0	0	0
>1.0	0	0	0	0
Median	.223	.20	.11	.17
Minimum	.083	.12	.01	.12
Maximum	.399	.22	.21	.24
SILICON				
0.0 - 2.5	20	80	40	20
2.5 - 5.0	80	20	40	80
<5.0	-	-	20	0
Median	4.0	1.4	3.00	4.17
Minimum	2.2	1.2	1.55	.59
Maximum	4.8	4.3	5.00	4.46
TIN				
0.001 - 0.030	100	100	100	100
>0.030	0	0	0	0
Median	.018	.017	.012	.013
Minimum	.003	.012	.010	.009
Maximum	.020	.022	.021	.019

approximately six feet above ground level.

In figure 6 the smoothed curves (3 consecutive half hourly readings averaged) of mean half hourly SO_2 concentrations are shown for ground level and an elevation of approximately 125 feet. Directly above these two curves is the curve of smoothed half hourly mean values of the difference in SO_2 concentration at 125 feet and at ground level; the curve of diurnal variation of the vertical gradient of SO_2 concentrations.

A large value of the gradient, or pronounced stratification, is an indication of diminished mixing through the layer, whereas a small gradient or only slight stratification is an indication of increased mixing through the layer. The gradient also reflects the elevation above ground of points of SO_2 emissions.

The interesting features revealed by these curves are listed and discussed below.

1. There is, on the average, 27 percent more SO_2 at a height of 125 feet than there is at ground level. There is an indication that emissions of SO_2 in March, in the area tested, are greater at upper levels than at ground levels. There is nothing in the curves to indicate whether or not SO_2 concentrations would continue to increase at still greater heights.

2. The three curves show nearly the same periodicity. Since concentrations and stratification are both



highest during the night when mixing is at a minimum and are lowest in the afternoon when mixing is at a maximum, it is evident that the process of diffusion is very important in distribution of pollutants.

3. Concentrations at 125 feet begin to decrease within an hour after sunrise. Concentrations at ground level do not begin to decrease until one hour later. One might expect the reverse order. Shortly after sunrise, the surface temperature begins to rise and mixing begins in a very thin layer near the surface. As the sun rises higher, the surface temperature continues to increase and the mixing layer becomes progressively thicker until it reaches the 125 foot level and eventually reaches levels at which there is virtually no contamination by SO_2 .

This sequence of events must lead first of to increasing SO_2 at the surface as the mixing brings to ground level the more polluted air from above. Such a mechanism was first described by Hewson^{5/} with reference to the Trail investigation. Note that this becomes evident at 0700. Once the mixing layer has extended to 125 feet, concentrations of SO_2 at that level will be reduced by the generally lower concentrations in the air below. This trend becomes evident at 0730. Of course, if the concentrations of SO_2 at some height above 125 feet were much greater, further thickening of the mixing layer might equalize or overcome this dilution by the cleaner air from below.

But since this does not happen, we can minimize the possibility that there are far greater amounts of SO_2 at still higher levels, without rejecting the possibility that slightly greater amounts of SO_2 may be found above 125 feet.

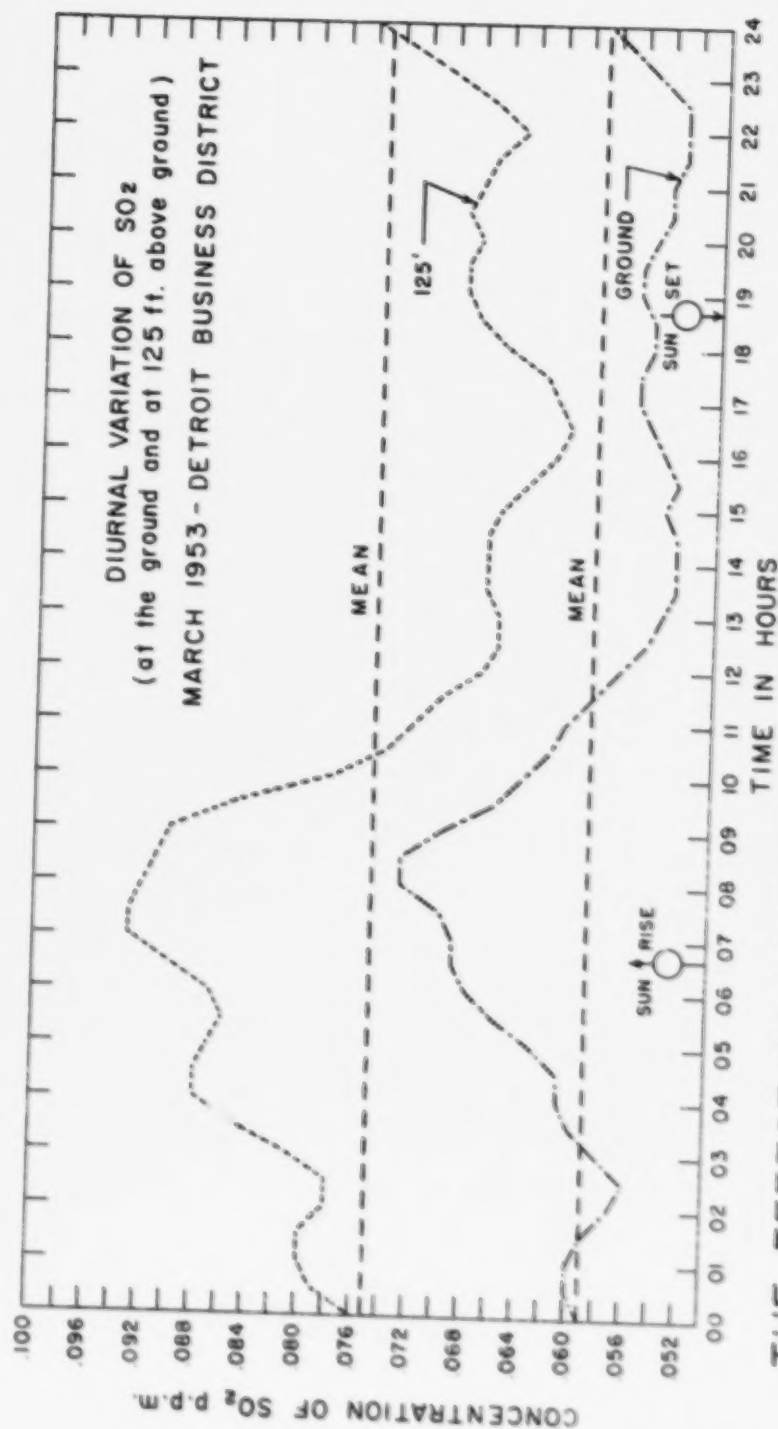
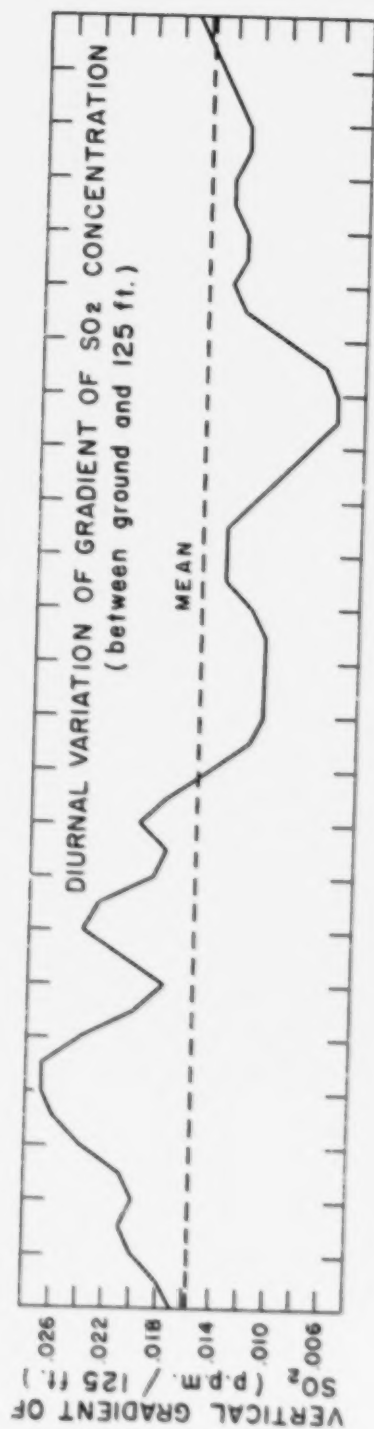
Finally, by 0900 a well marked downward trend is evident at both levels suggesting that the mixing thickness has penetrated into the layers of air previously uncontaminated by the SO_2 .

In figure 7 are shown the day to day changes for SO_2 concentration at ground level and at 125 feet together with the gradient of SO_2 between the two levels.

As in figure 6, where mean half hourly values were considered, the two concentration curves are in phase. Their correlation coefficient is .825, compared to the value .549 which is significant at the 1 percent level.

But, unlike the curve of half hourly values, the gradient curve is not in phase with the two concentration curves. Evidently large SO_2 gradients can occur on days of high or low pollution. There is some evidence that changes in the mean daily SO_2 gradient may be related to the different ratio between 125 feet and ground level emissions in different wind directions, as well as to changes in mixing. There are insufficient data in this series to verify this.

Figure 8 presents the values obtained with the high volume samplers using fiber glass filters when the samplers



THE EFFECT OF ELEVATION ON SO₂ CONC. BY TIME OF DAY

FIGURE 6

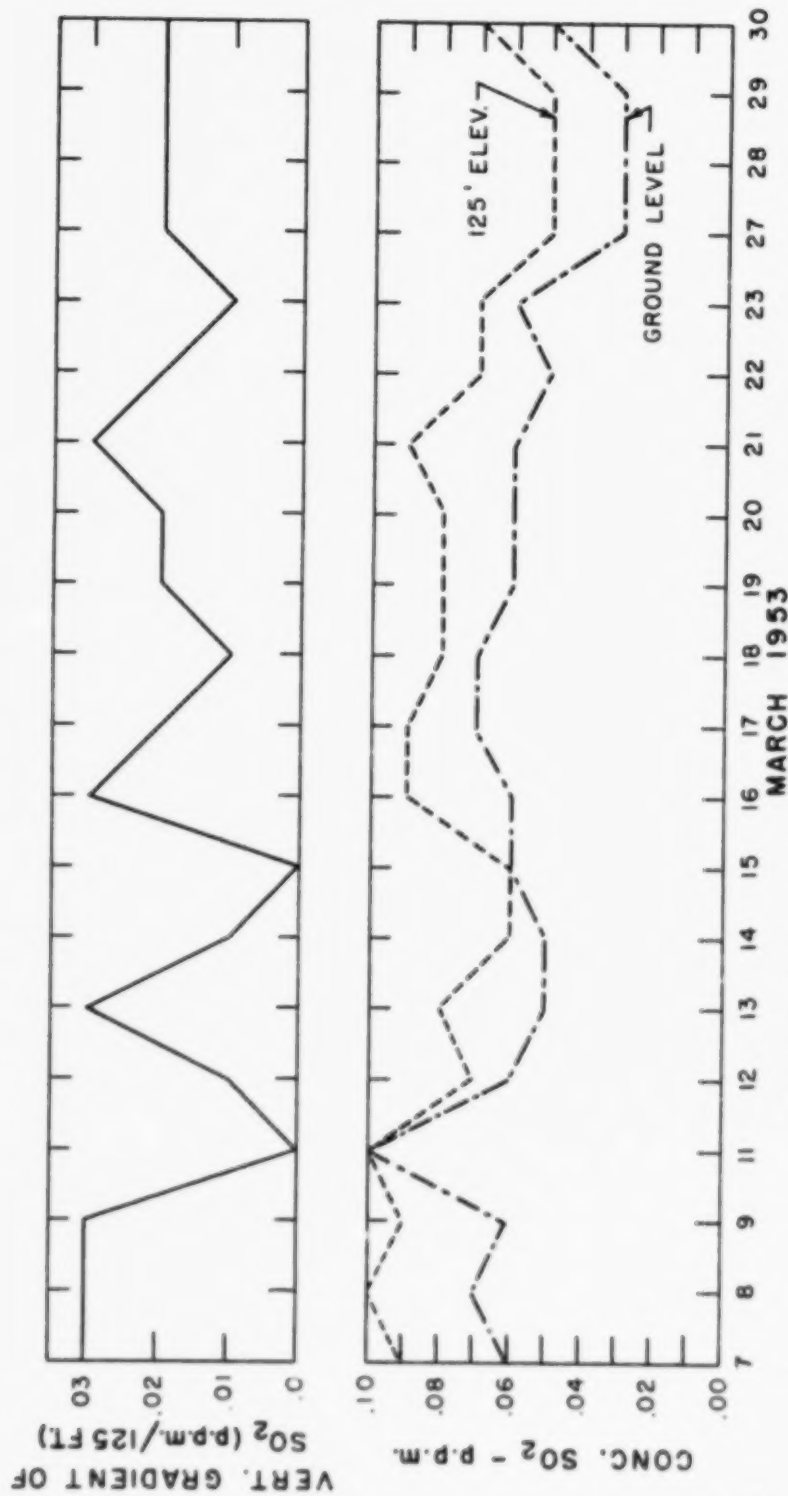


FIGURE. 7

were located at different elevations and the comparison of the fiber glass filter media to the pleated filter media.

The median value for the fiber glass filters was 350.5 micrograms per cubic meter of air and the median value for the pleated filters was 329.3 micrograms per cubic meter of air, indicating that the collecting efficiency of the two types of filters were similar, on a weight basis, when sampling the general atmosphere, although, it is known that the fiber glass filter is much superior for the collection of particles smaller than 0.3 microns in size.

Since the fiber glass filter is cheaper and much superior to the pleated filters for laboratory analysis, and apparently a satisfactory collecting medium, they will be used in future studies.

The vertical profiles of SO_2 and particulate air pollution provide an interesting comparison. Through the first 125 feet, the average concentration of SO_2 increases from .059 to .075 parts per million or 27 percent. In the case of particulate pollution, the average concentration decreases from 350 to 338 micrograms per cubic meter through the first 125 feet. However, statistical tests show that there is more than a 50 percent chance of this large a difference when the pollution at the two levels is identical.

These two profiles result from a combination of factors. One is the different rates of emission of the

34.4

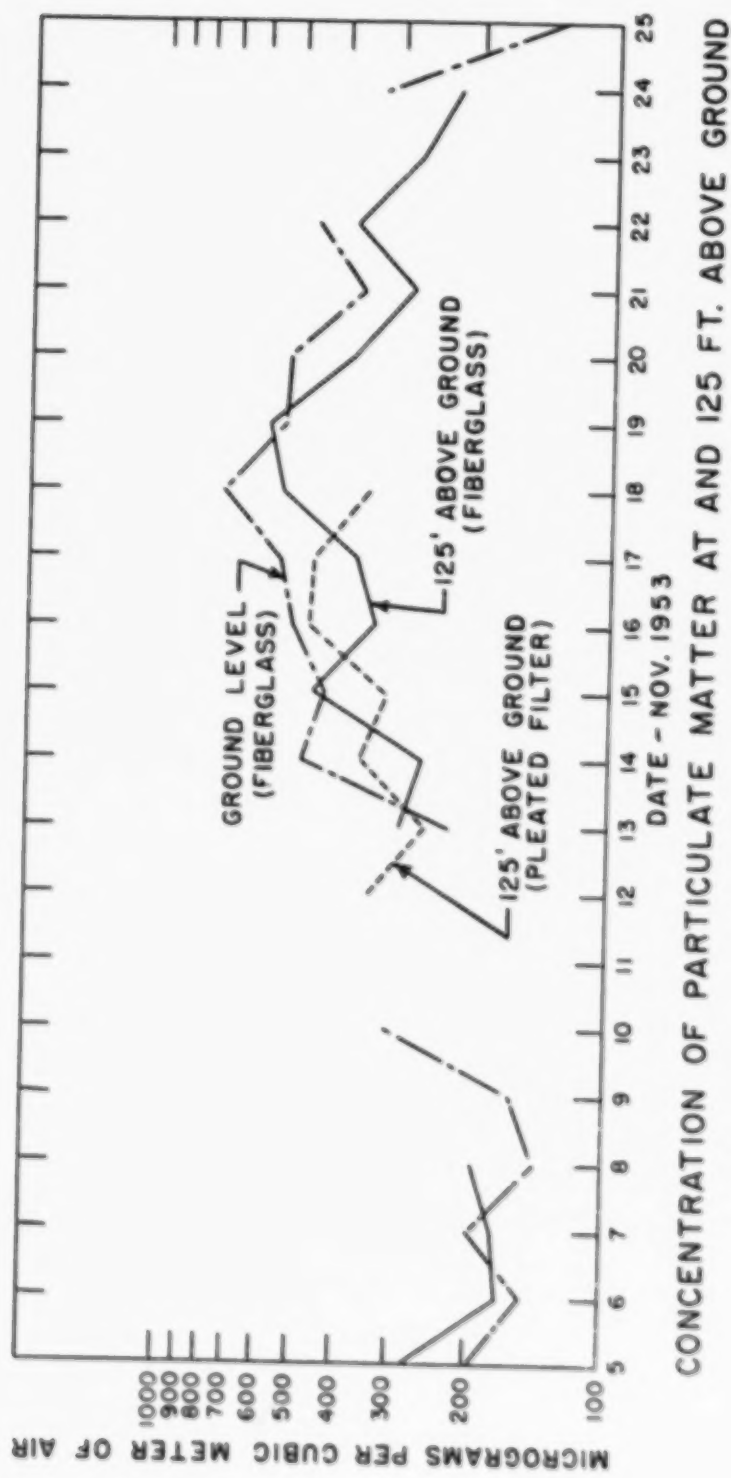


FIGURE 8

two types of pollution at the various levels. Others are the degree of mixing of various levels of the atmosphere, rate of fall of the particles involved and wind direction.

The organic particulates in the atmosphere are of much concern since many believe that substances in this group are responsible for the higher cancer rates found in people living in urban areas. An investigation of the concentrations of this fraction of the particulates found in the atmosphere at the two levels was made and the results, from samples collected at the Majestic Building, are shown in figure 9. It may be seen that there was no daily pattern to the values found. However, the mean values were quite similar, being 54.8 at ground level and 52.2 micrograms per cubic meter of air at the 125 foot level. This uniformity could be a result of complete mixing of the organic material within the 125 feet or because of equal discharges of organic material at ground elevation and at higher elevations, or a combination of these influences.

A study was made to determine the variation in concentration of selected elements with elevation above ground level. These data are presented in table 13. The manganese concentrations found at ground level were similar to those found at that level in earlier studies. It is noted that the value at the 125 foot elevation was approximately one half that found at ground level. It may

35-4

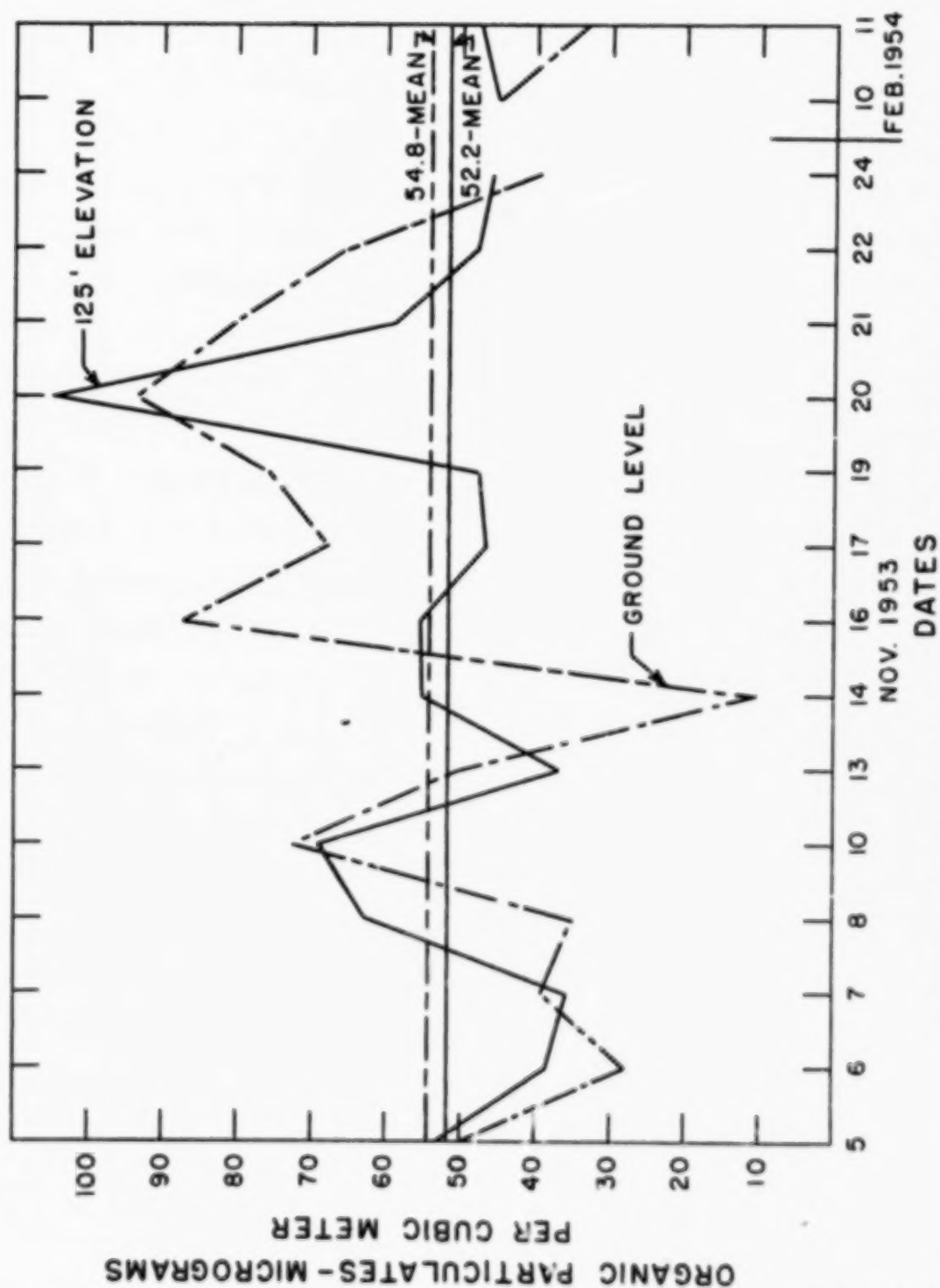


FIGURE 9

CONCENTRATION OF ORGANIC PARTICULATES
AT AND 125 FEET ABOVE GROUND

be that most of the manganese found originates from the earths' surface. The lead concentrations found at ground level were approximately the same as at the 125 foot elevation. This is surprising as it is commonly believed that the lead from automobile exhausts is a major source of atmospheric lead. However, this finding would lead one to suspect that lead was also being discharged from sources at an elevation higher than those from the automobile, as it is felt, as earlier stated, that there is not complete mixing of the atmosphere between these two elevations.

It may also be noticed that the mean iron, tin, magnesium, and sodium concentrations are appreciably higher at ground elevation than at the 125 foot elevation. This was also true for titanium and vanadium. Copper and beryllium concentrations were higher at the 125 foot elevation than at ground level.

PARTICLE FALL

Table 14 presents the particle fall data, as collected by the Detroit Smoke Abatement Bureau, for the years, 1950, 1951, 1952 and 1953 for twenty stations. Map number one shows the location of these stations and their locations are given specifically on page 37. A study of this table will reveal those areas which have shown considerable improvement by month, for the past four years, those stations which remain approximately the same, and those stations showing considerable increase in particle fall

TABLE 13 - The influence of elevation on selected Elements.

Element	Ground Level			125' Level		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Manganese	0.11	2.52 ^{1/}	0.86	0.08	1.17	0.42
Lead	0.20	4.00	2.29	1.63	2.62	2.05
Tin	0.01	0.16	0.04	0.01	0.06	0.02
Iron	1.40	14.20	7.20	0.13	9.20	4.15
Copper	0.01	0.58	0.24	0.40	0.92	0.51
Silver	0.001	0.0012	0.0006	0.005	0.001	0.0006
Titanium	0.03	0.97	0.31	0.007	1.05	0.042
Vanadium	0.001	0.210	0.048	0.0016	0.015	0.004
Magnesium	2.10	11.60	6.12	3.80	5.44	4.63
Sodium	1.04	12.90	4.69	1.55	5.80	3.00
Potassium	0.04	6.12	2.88	0.35	4.20	2.05
Strontium	0.01	0.45	0.29	0.17	0.57	0.36
Beryllium	0.0001	0.0006	0.0001	0.0001	0.0003	0.0002
Arsenic	0.006	0.093	0.039	0.002	0.061	0.034

^{1/} Micrograms per cubic meter of air.

LOCATION OF PARTICLE FALL CONTAINERS

1. 37 E. Jefferson - (Leib)
2. 3480 Russell - (Benton)
3. Wayne Student Center - 5060 Cass Avenue
4. Martin H. - 3510 National
5. 1450 Twenty - first Street - (Porter & Bristol)
6. 7831 W. Fort - (Glennian)
7. 4833 Ogden - (Arnold & Michigan)
8. W. Chicago and Lauder
9. 17045 Grand River - (Lindsay & Oakfield)
10. 11762 Kentucky - (Plymouth & Grand River)
11. 6075 Begole - (Cobb Place & Ironwood)
12. 10410 E. Jefferson - (Lycaste & Hart)
13. 492 Drexel - (Averhill & Essex)
14. 4800 Eastlawn - (Forest)
15. 8000 Gratiot - (Van Dyke)
16. 2325 E. Grand Blvd. - (Chene)
17. 8841 Woodward - (Gladstone & Holbrook)
18. 18460 Warrington - (Pickford & Margareta)
19. 18875 Ryan Road - (Robinwood & 7 Mi. Rd.)
20. 11765 Glenfield - (Gunston & Gratiot)

load. For example, in March station 11 has shown a steady decrease in pollution over the years while station 10 has shown a steady increase. It is not the purpose of this report to give a careful analysis of these data by station, but rather to use these data to indicate, by this type of sampling, the trend of the settled particle situation for the community as a whole. This analysis is presented in figure 10. The mean value shows that the settled particle pollution is increasing yearly, with a low of 58 tons of matter per square mile in January of 1950 to a high of 77 tons per square mile in December of 1953, an increase of 19 tons per square mile. These data also show that generally the particle fall is relatively high in the winter and spring and relatively low in the summer and fall. This of course, is not in harmony with the results obtained with the high volume air samplers. This is not unexpected as the methods of sampling are different.

SULFUR DIOXIDE

Measurements of sulfur dioxide concentrations in the atmosphere were made with the Thomas Autometer at stations 4 and 24. At stations 20 and 21, the sulfur dioxide concentrations were obtained with the Wilson Automatic Impinger using as the collecting media, a solution made from the same formula as that used in the Thomas Autometer and the difference in pH being calculated as the sulfur dioxide concentration.

TABLE 14 -
PARTICLE FALL DATA^{1/} BY MONTH AND YEAR FOR TWENTY STATIONS LOCATED WITHIN
THE DETROIT CITY LIMITS. ALL RESULTS CALCULATED IN TONS PER SQUARE MILE
PER MONTH

STATION NUMBER	JANUARY					FEBRUARY					MARCH					APRIL				
	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean
1	92.8	115.5	93.6	84.9	96.7	49.4	97.6	91.5	108.1	86.7	94.5	106.3	105.9	97.1	101.0	76.6	104.1	105.0	96.3	95.7
2	78.3	80.9	67.0	87.5	79.4	28.0	93.2	81.8	112.9	79.0	83.1	117.3	91.0	70.5	90.5	107.2	110.3	79.6	94.1	97.8
3	99.1	91.9	68.7	84.5	83.8	45.5	79.2	57.8	116.4	74.7	80.5	94.1	73.1	46.4	73.5	57.8	57.3	82.3	139.2	84.2
4	49.9	58.7	54.7	76.6	62.5	25.4	49.0	63.4	80.5	54.6	44.6	81.4	72.2	48.6	61.7	42.9	71.3	60.0	67.8	60.5
5	98.9	75.7	90.2	70.9	83.9	24.5	82.3	67.0	81.4	63.8	91.5	206.7	82.3	150.1	133.2	93.6	102.0	76.6	93.2	91.4
6	97.1	122.9	110.3	130.8	115.3	60.0	104.6	79.2	177.2	105.2	103.7	51.2	84.1	119.9	92.2	90.6	140.6	96.7	174.6	125.7
7	71.8	85.7	63.4	77.5	74.6	23.2	59.5	47.7	75.3	51.4	48.6	73.9	64.3	57.8	61.2	42.9	75.3	62.1	73.5	63.5
8	26.7	19.4	39.0	42.0	31.8	15.3	28.4	35.0	45.5	31.1	23.6	60.8	52.5	28.0	41.2	24.9	45.9	50.8	57.8	44.9
9	25.4	17.1	44.2	29.3	29.0	5.7	19.6	-	30.6	18.6	36.8	199.9	70.9	28.9	84.1	34.1	21.0	61.3	35.2	37.9
10	55.7	66.5	95.4	94.1	77.8	52.1	60.8	113.3	270.9	124.3	84.5	95.4	133.9	286.2	175.0	84.0	78.8	107.2	212.2	120.6
11	48.1	61.3	56.9	60.8	56.8	28.0	53.8	40.3	74.0	49.0	73.1	66.3	55.1	50.8	61.8	64.8	84.8	68.2	66.5	65.3
12	140.5	243.7	88.4	89.7	140.6	58.6	124.3	70.4	60.8	78.5	65.6	135.2	125.6	67.4	98.5	72.2	126.0	77.5	69.1	86.2
13	53.8	50.3	62.1	53.4	54.9	35.0	44.2	36.8	69.1	46.3	70.5	58.2	56.0	65.2	62.5	63.4	59.5	30.6	43.3	49.2
14	48.6	43.3	41.6	49.9	45.9	22.3	45.5	36.3	56.9	40.3	45.4	44.6	54.3	46.4	47.9	47.7	59.1	57.8	54.7	54.8
15	37.6	52.5	46.4	41.1	44.4	16.6	45.8	34.1	52.5	37.3	44.2	45.1	57.3	50.3	49.2	40.3	41.6	46.8	44.2	43.2
16	46.8	189.5	164.5	188.2	147.8	101.1	214.4	135.7	185.0	154.1	176.8	229.7	168.5	129.1	176.0	108.5	165.0	119.5	113.8	126.7
17	94.5	70.9	81.4	31.5	69.6	60.4	76.6	54.7	84.0	68.9	72.2	112.9	72.2	56.9	78.7	104.6	86.6	70.4	67.8	82.4
18	21.9	231.9	26.7	23.6	78.0	11.4	24.5	29.8	45.1	27.7	25.4	57.8	33.3	29.0	36.1	25.8	44.6	38.5	41.1	37.5
19	35.8	41.6	44.2	34.1	39.0	12.3	32.8	30.6	46.8	30.6	35.9	45.5	35.4	21.9	34.7	42.0	35.4	39.4	53.4	42.6
20	30.6	45.4	53.8	49.4	45.1	24.9	51.1	41.6	61.3	44.7	36.8	60.8	40.3	42.4	45.1	48.1	49.9	36.3	56.9	47.8
Mean	62.32	88.79	69.63	70.00	72.70	34.99	69.37	60.37	90.72	63.35	66.92	97.36	76.93	74.60	80.21	63.60	76.97	68.18	82.74	72.90

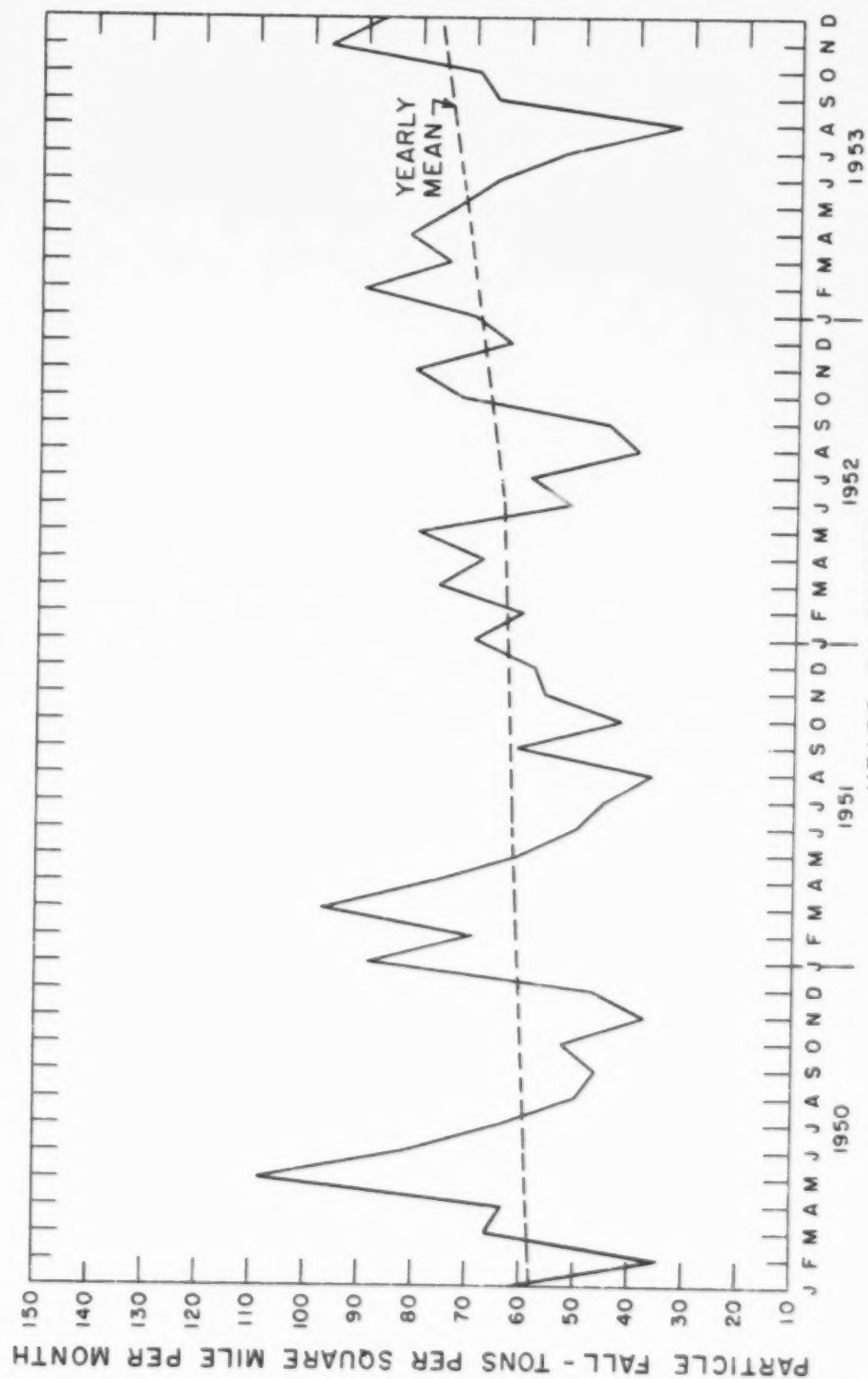
^{1/} DATA OBTAINED FROM THE DETROIT SMOKE ABATEMENT BUREAU

TABLE 14 - CONTINUED

STATION NUMBER	MAY					JUNE					JULY					AUGUST				
	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean
1	143.1	80.9	94.5	96.3	103.7	117.1	-	60.4	69.1	82.2	91.5	75.7	72.2	59.1	74.6	77.9	73.9	45.1	39.4	59.1
2	152.3	73.9	109.0	86.7	106.2	106.3	83.1	109.0	72.6	92.8	97.1	57.3	117.3	70.5	85.6	85.3	55.1	46.8	35.0	55.6
3	106.8	66.9	97.1	97.1	92.0	87.5	49.0	61.3	78.3	59.0	70.0	65.2	62.6	53.8	62.9	56.5	37.6	45.1	14.0	40.8
4	59.5	51.2	68.3	88.6	59.4	69.6	27.6	52.5	65.6	53.8	49.4	40.0	45.1	52.5	46.8	54.3	32.4	38.5	30.2	38.9
5	143.5	73.1	111.1	81.4	102.3	114.2	63.9	78.3	81.4	84.5	80.1	81.4	69.1	58.2	72.2	30.2	71.6	48.1	40.3	47.6
6	287.9	155.3	175.5	135.7	188.6	214.4	144.4	123.0	172.0	163.5	147.5	134.8	173.7	188.6	161.2	134.3	78.8	93.6	78.3	96.3
7	124.3	73.1	51.3	56.0	78.7	127.8	32.4	50.3	92.3	75.7	64.3	38.9	63.6	59.5	56.8	36.3	34.1	44.6	46.8	40.5
8	43.3	46.8	45.9	37.2	43.3	31.5	26.3	30.6	43.6	33.1	32.4	25.4	39.8	28.4	31.5	37.2	17.1	21.9	13.1	22.3
9	62.6	29.8	53.9	33.3	47.4	34.1	-	39.4	29.3	34.3	26.3	20.1	-	21.0	22.5	4.4	24.5	34.1	15.8	19.7
10	77.0	58.2	77.0	215.3	105.9	67.4	46.4	55.1	120.8	72.4	55.6	36.3	38.5	43.8	49.6	39.4	48.6	34.1	63.5	46.4
11	98.5	58.6	68.6	60.4	71.8	93.2	38.9	52.9	65.6	62.7	62.1	36.7	56.5	56.9	53.1	30.6	21.0	36.1	28.0	29.4
12	130.4	-	106.8	62.1	99.8	90.1	-	57.8	81.8	76.6	70.5	45.9	58.8	45.1	55.1	71.8	42.0	39.8	31.7	46.8
13	57.3	29.3	70.5	44.2	50.3	54.7	25.4	40.7	-	40.3	45.9	30.6	35.4	-	37.3	34.6	15.6	27.6	-	25.9
14	51.2	42.0	61.3	51.6	51.5	45.1	29.8	34.1	37.6	35.7	31.9	32.3	35.4	35.4	33.8	38.5	19.7	29.4	28.4	29.0
15	151.2	28.9	50.3	41.1	67.9	46.8	35.9	31.5	55.6	42.5	42.9	28.0	33.3	38.9	35.8	35.9	16.2	22.3	21.4	24.0
16	198.2	145.7	114.2	116.4	143.5	132.6	113.3	60.8	101.5	102.1	136.1	45.1	73.5	77.9	83.2	117.3	88.4	68.3	48.6	80.7
17	71.8	58.2	58.6	67.1	63.9	50.3	-	39.4	75.5	55.1	51.6	43.8	56.5	49.0	50.2	45.9	74.4	35.4	25.4	45.3
18	71.3	35.9	56.0	30.6	48.2	41.1	28.0	28.9	31.9	32.5	25.8	16.2	29.8	9.2	20.3	12.7	12.7	19.3	15.8	15.1
19	57.4	37.2	51.2	45.1	47.7	64.8	35.0	35.7	28.0	40.4	62.1	25.3	32.8	30.6	37.7	29.3	15.3	29.8	16.2	22.7
20	71.8	19.7	62.1	50.8	51.1	52.5	22.3	-	34.6	35.5	42.4	21.4	35.0	38.5	34.3	24.1	11.8	34.1	24.5	23.6
Mean	106.47	61.25	80.21	73.50	81.22	82.08	50.11	51.99	66.87	54.36	64.28	45.02	59.42	53.52	54.92	50.33	36.72	39.80	32.55	40.48

TABLE 14 - CONTINUED

STATION NUMBER	SEPTEMBER					OCTOBER					NOVEMBER					DECEMBER				
	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean	1950	1951	1952	1953	Mean
1	31.5	77.0	67.8	72.5	62.2	65.2	82.6	41.1	64.2	63.3	46.4	22.3	107.6	129.7	94.0	98.5	86.2	110.7	148.7	111.0
2	56.9	77.0	52.9	79.6	66.6	48.1	52.5	113.3	106.6	80.1	22.3	62.1	111.6	126.6	80.7	38.1	82.3	74.8	127.9	90.8
3	52.9	59.5	45.5	71.8	57.5	77.0	32.4	104.1	67.3	70.2	51.5	64.8	86.2	110.6	78.3	44.2	51.2	66.1	108.4	67.5
4	17.5	39.8	38.5	66.1	40.5	43.8	36.8	70.0	63.3	53.5	35.4	52.8	73.1	73.0	58.8	28.9	46.4	49.0	121.2	63.9
5	61.7	93.6	56.9	64.3	59.1	65.6	59.1	67.1	77.4	72.3	50.8	70.5	112.5	100.4	83.6	56.9	78.8	70.9	117.3	81.7
6	101.5	79.2	118.2	188.9	117.0	129.5	86.6	208.7	112.0	134.2	92.8	98.5	70.9	132.3	98.6	75.3	56.0	115.1	139.8	96.6
7	59.5	72.2	51.6	63.5	61.7	60.4	58.2	61.3	74.8	63.7	50.3	59.1	109.8	88.1	71.8	30.2	72.6	85.8	89.8	64.6
8	20.6	30.6	24.9	26.7	25.7	20.1	22.3	42.9	42.0	31.8	10.9	22.8	38.1	33.2	26.3	14.4	30.6	23.6	60.2	32.2
9	16.7	141.8	23.8	28.9	52.5	17.5	14.9	56.0	27.9	29.1	11.8	18.4	39.4	35.0	26.2	11.3	28.0	28.0	73.9	35.3
10	42.9	54.7	31.1	104.1	77.6	38.1	31.5	79.2	168.2	78.3	32.0	90.6	82.7	163.7	92.3	92.8	57.3	113.8	158.4	105.6
11	58.9	71.8	52.1	68.7	62.9	58.6	54.7	66.1	69.5	62.2	22.8	57.8	33.3	97.8	52.9	29.6	42.9	52.9	90.3	53.9
12	47.7	61.3	49.9	70.5	57.4	73.1	44.6	62.6	71.2	82.9	40.3	64.3	95.4	102.2	75.1	58.6	84.0	83.6	142.0	87.6
13	21.9	35.9	33.3	-	30.4	27.1	27.6	56.4	-	37.0	17.9	31.1	218.4	-	66.9	42.4	51.2	47.7	-	43.8
14	24.5	17.1	44.6	56.9	35.8	36.8	27.1	62.1	45.6	42.5	27.1	54.7	54.7	102.7	58.8	37.6	68.3	40.2	86.3	58.1
15	42.0	41.1	23.6	47.3	38.5	45.5	35.0	59.6	43.4	45.6	23.2	42.9	67.8	98.2	58.0	28.0	53.4	34.6	77.4	45.9
16	124.3	103.3	73.5	91.5	98.2	138.7	89.3	114.6	114.2	114.2	106.3	64.3	183.8	208.9	84.8	146.6	114.2	135.7	177.0	143.4
17	57.8	55.6	42.4	62.1	54.5	32.0	34.6	58.5	61.1	46.8	66.1	75.3	52.5	93.4	71.8	44.6	77.0	68.3	100.9	72.3
18	22.8	37.6	19.7	38.1	29.6	16.2	15.3	30.6	26.6	22.2	14.0	30.2	43.8	37.2	31.3	14.8	21.4	24.9	62.0	30.8
19	39.8	37.6	23.6	24.5	31.4	30.2	24.1	37.2	45.6	34.3	16.2	28.0	22.8	66.4	33.4	14.8	29.8	34.1	79.7	39.6
20	29.3	38.1	31.9	49.0	37.2	30.6	22.3	41.6	43.4	34.5	21.0	52.5	17.5	67.3	39.6	29.3	45.9	51.2	104.4	57.7
Mean	46.54	61.24	45.28	66.06	55.32	52.71	42.58	72.65	69.70	59.01	37.96	56.70	81.10	97.19	64.21	47.50	58.88	63.54	87.16	68.62



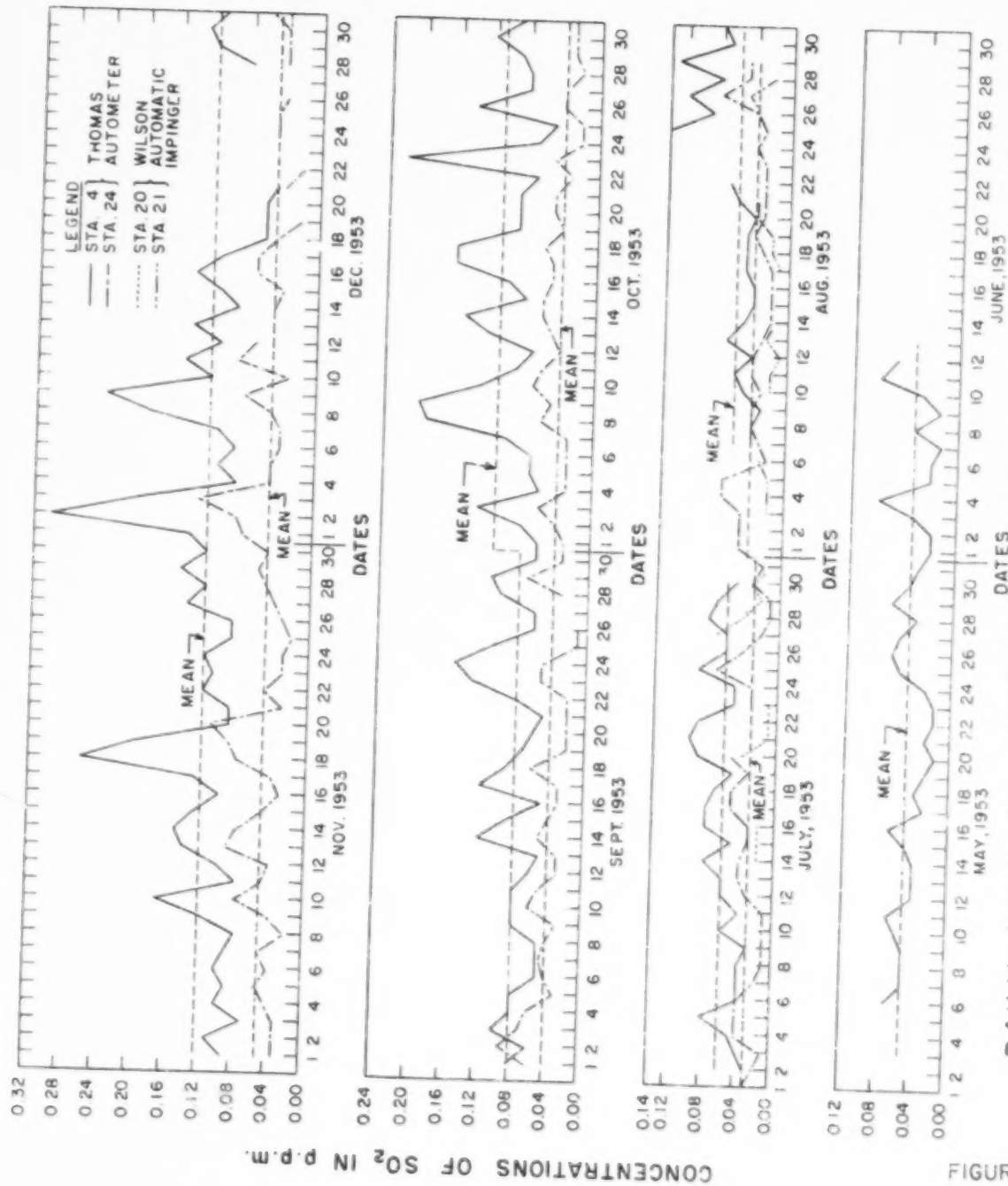
MONTHLY MEAN PARTICLE FALL AT 20 STATIONS
CITY OF DETROIT - 1950-1953

FIGURE 10

Figure 11 presents the daily sulfur dioxide concentrations for the various stations for the period May 6 through December 31, 1953. At station 4, the monthly mean ranged from a low of 0.05 parts per million in May to a high of 0.12 parts per million in November and December. Of special interest is the relatively high daily concentrations found at this station during certain periods of October, November and December, reaching a high of 0.30 parts per million on December 2, 1953. At station 24, a range of from 0.03 parts per million in July to a high of 0.05 in November and December was found. At no time did the highest daily values found at this station go as high as the values obtained at Station 4. A comparison of the data obtained at station 4 to those at station 24 shows general agreement in the fluctuations of the concentrations.

Table 15 shows the distribution of the frequency of sulfur dioxide measurements at four stations in Detroit during 1953. Because of the disparity of the total number of samples between stations 20 and 21, versus stations 4 and 24, it is difficult to make a statistical study between stations. However, from the limited data obtained at stations 20 and 21, it is indicated that these stations had appreciably less sulfur dioxide than stations 4 and 24, with station 4 having the highest sulfur dioxide concentrations.

Table 16 shows the relationship of sulfur dioxide



DAILY AVERAGE SO_2 CONCENTRATIONS AT 4 STATIONS
 MAY-1953 — DECEMBER-1953

FIGURE II

TABLE 15 - DISTRIBUTION OF THE FREQUENCY OF
SULFUR DIOXIDE RECORDED AT FOUR
STATIONS IN DETROIT DURING 1953

Concentration Range	NUMBER				PERCENT			
	Station 4	20	21	24	4	20	21	24
0.00 - 0.05	271	39	50	518	34	98	98	78
0.06 - 0.10	333	1	4	131	42	2	7	20
0.11 - 0.15	113	0	0	6	14	0	0	1
0.16 - 0.20	48	0	0	4	6	0	0	1
0.21 & Over	30	0	0	0	4	0	0	0
TOTAL	795	40	50	649	100	100	100	100

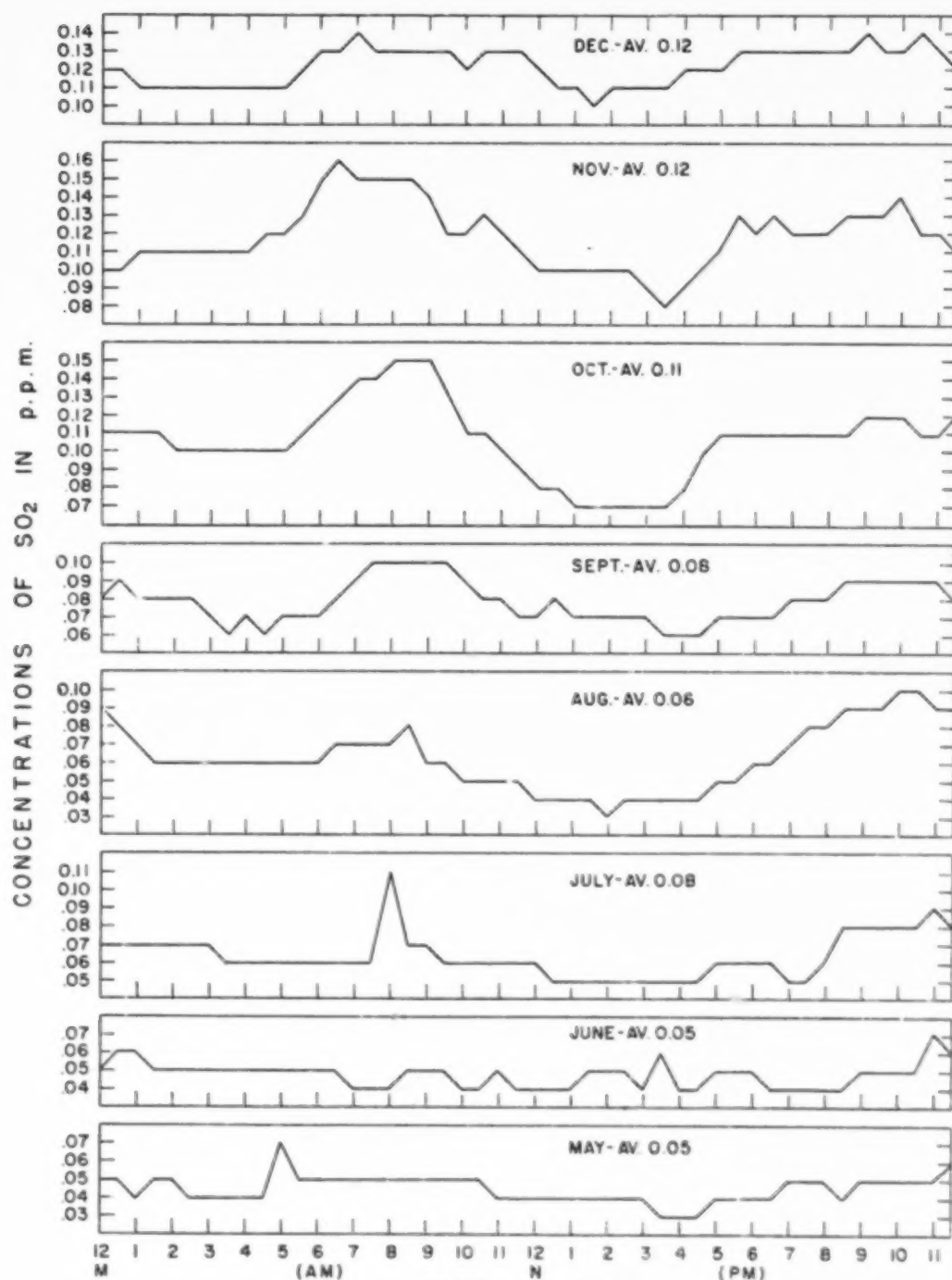
TABLE 16 - DISTRIBUTION OF THE FREQUENCY OF THOMAS AUTOMETER SIX HOUR AVERAGE READINGS (CALCULATED AS SO₂) RECORDED IN DETROIT FOR THE CALENDAR YEARS, 1953, 1952 and 1951.

Concentration Range	NUMBER			PERCENT		
	1953	1952	1951	1953	1952	1951
0.00 - 0.05	878	587	303	57	57	54
0.06 - 0.10	469	295	163	30	28	29
0.11 - 0.15	119	111	55	8	11	10
0.16 - 0.20	52	33	23	3	3	4
0.21 & Over	30	13	15	2	1	3
Total	1548	1039	559	100	100	100

concentrations recorded on the Thomas Autometers at two locations during the years 1951, 1952 and 1953. These figures indicate that the sulfur dioxide concentrations in the Detroit atmosphere have remained essentially unchanged during this three year period.

Figure 12 presents the monthly average half hourly sulfur dioxide concentrations for station 4, as well as the monthly average. During the month of May, a peak of 0.07 parts per million of sulfur dioxide occurred at 5:00 A. M. and reached a low of 0.03 parts per million between 3:30 and 4:30 P. M. Both May and June had mean concentrations of 0.05 parts per million. In July, an appreciable peak concentration of 0.11 was obtained at 8:00 A. M., decreasing rapidly to a low in the early afternoon and then rising slowly in the evening hours.

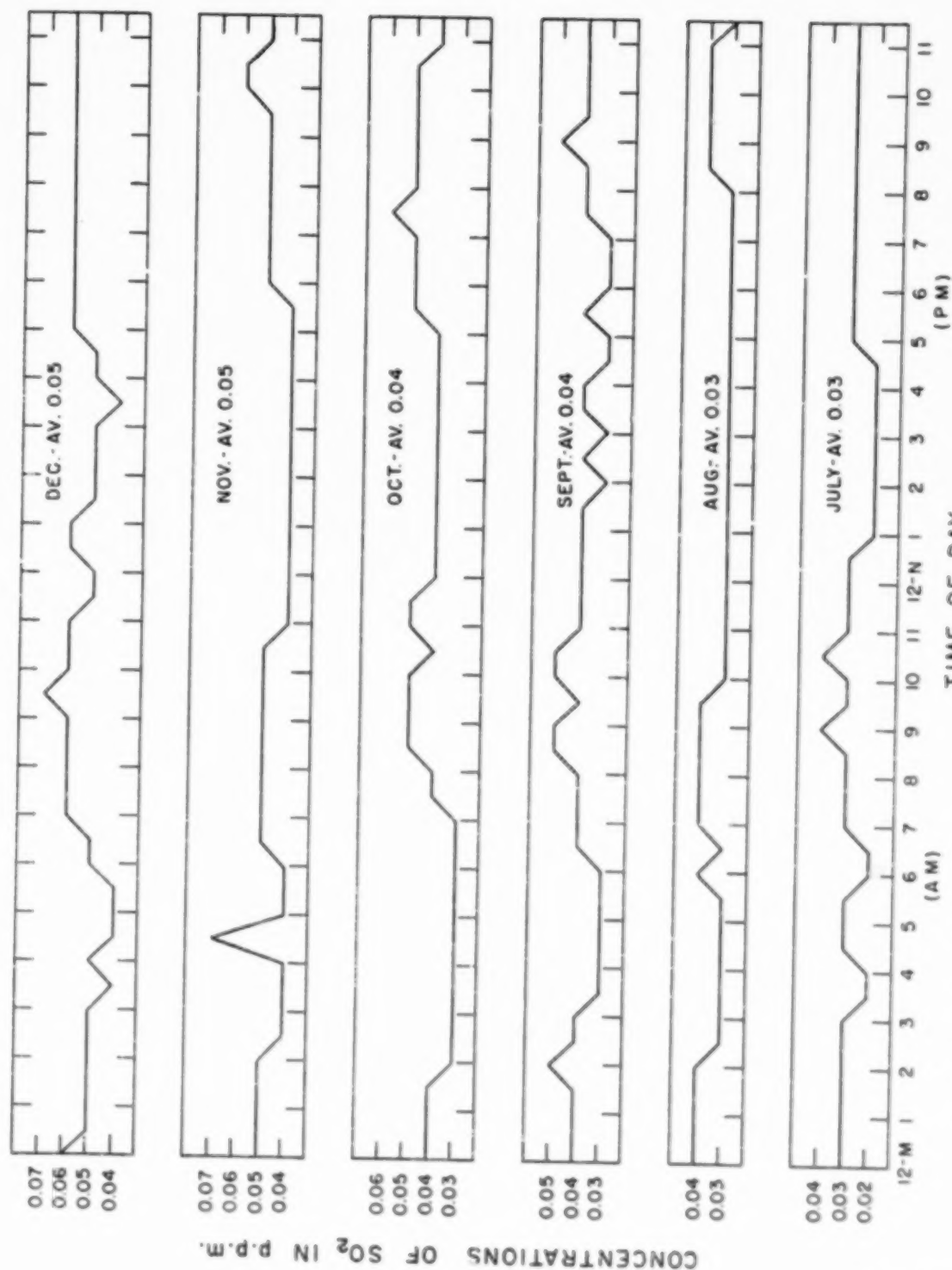
In September, October and November, the highest concentrations occurred during the early morning hours, decreasing steadily after sunrise and reaching a low in the early afternoon and subsequently rising after sunset. At station 4 the monthly average ranged from a low of 0.05 parts per million in May to a high of 0.12 in November and December. Figure 13 presents the monthly average sulfur dioxide concentrations for station 24. In comparing figure 13 to figure 12, it may be observed that the hourly fluctuations were not as great for this station as at station 4. It may also be noted that the concentra-



MONTHLY AVERAGES OF HALF HOURLY
SO₂ CONCENTRATIONS AT STATION 4
MAY-DEC. 1953

FIGURE 12

40 A



MONTHLY AVERAGES OF HALF HOURLY SO_2 CONCENTRATIONS
AT STATION 24 — JULY - DEC., 1953

FIGURE 13

tions are generally lower. The monthly average ranges from a low of 0.03 in July to a high of 0.05 in December, roughly one half the concentrations found for station 4.

OZONE

Ozone determinations using the alkaline potassium iodide method were made at the Herman Kiefer Hospital during 1953, by the Bureau of Industrial Hygiene of the Detroit Department of Health. Table 17 presents these data and as may be seen, the values ranged from a low of "none found" to a high of 1.7 parts of ozone per hundred million parts of air (pphm).

In Los Angeles ozone is thought to be a major factor in causing eye irritation, plant damage, rubber cracking and reduced visibility found during periods of smog in that area. It is therefore interesting to compare the results obtained in Los Angeles to the results obtained in Detroit; using the same method of analysis.

In Los Angeles, during a week of higher than normal pollution, the average values ranged from a low of 2.0 pphm to a high of 22.0 pphm. During a "normal" fall week the values ranged from 3.0 to 7.5.^{6/}

This comparison reveals that the ozone concentrations in Detroit are much lower than those found in Los Angeles. This does not mean that Detroit will not or does not have air pollution; it just means that the composition of the atmospheric pollutants in Detroit is

TABLE 17 - OZONE¹ CONCENTRATIONS OBTAINED IN DETROIT

DATE	TIME	CONC ² PPHM	DATE	TIME	CONC ² PPHM
1-2	1500	0.98	4-1	1430	0.65
1-5	1500	0.65	4-7	1400	0.82
1-6	1300	0.76	4-9	1400	0.27
1-8	1300	0.60	4-13	1500	none found
1-9	1500	0.82	5-5	0830	1.70
1-12	1300	0.38	5-6	1130	0.65
1-13	1400	0.76	5-7	1500	0.66
1-14	1400	0.33	5-8	0830	0.75
1-15	1400	0.22	5-12	1500	1.26
1-16	1530	0.55	5-20	0830	0.62
1-19	1400	0.65	6-4	1400	0.55
1-21	1400	0.27	7-1	1500	0.78
1-22	1400	0.27	7-13	0900	0.53
1-23	1400	0.05	7-14	0900	0.82
1-26	1500	0.16	7-16	0845	0.94
1-27	1400	0.38	7-20	0900	0.92
1-28	1500	0.82	8-4	1045	0.35
1-29	1500	0.45	8-11	0830	0.24
1-30	1515	0.29	8-13	0830	none found
2-2	1500	0.16	8-14	0830	0.21
2-3	1500	0.43	8-25	1000	1.00
2-10	1500	0.16	8-26	1500	0.45
2-11	1530	0.10	8-27	0830	0.45
2-12	1530	0.38	8-28	1230	0.82
2-12	1530	0.38	9-2	0845	2.50
2-16	1500	0.38	9-3	0930	0.75
2-17	1530	0.37	9-4	0900	0.43
2-18	1500	0.33	9-8	0900	0.12
2-19	1400	0.16	9-9	1400	0.32
2-23	1400	0.22	9-11	1010	0.23
2-24	1430	0.38	9-14	1130	0.23
2-25	1430	0.43	9-15	0855	0.02
3-3	1530	0.11	9-16	1010	0.04
3-4	1530	0.43	9-17	1130	0.93
3-10	1100	0.70	9-18	0855	0.05
3-11	1400	0.52	9-21	1400	0.49
3-12	1430	0.34	9-22	1500	0.21
3-13	1500	0.12	9-23	0830	0.17
3-16	1430	0.52	9-24	0800	0.32
3-17	1500	0.40	9-25	0900	0.14
3-23	1500	0.58	9-28	1400	0.68
3-24	1530	0.82	9-29	1430	0.34
3-25	1430	0.52	10-16	1400	0.34
3-27	1400	0.54	10-19	1400	0.45
3-30	1400	0.27	10-23	0900	0.68
			11-20	1100	0.10

¹Alkaline KI Method²Parts of ozone per hundred million parts of air by volume (PPHM)

different than in Los Angeles.

NATURAL AIRBORNE RADIOACTIVITY AND SOILING POWER
OF POLLUTANTS.

It has been reported that natural airborne radioactivity arising from the earth (Radon) could be determined and used as an index of atmospheric stability and indirectly of pollution. It was therefore decided to sample for this material and to compare the results with those obtained by light reflectance measurements (soiling power) made on air samples collected by passing the air through filter paper.

The data were obtained as follows: All samples were taken at the one location, the first floor of the Herman Kiefer Hospital, and at approximately the same time of day by the Bureau of Industrial Health of the Detroit Department of Health. AM samples cover the period 0800-0830, and PM samples cover the period 1500-1530. All samples are for 30 minute periods, and contain the filterable material from 15 cubic feet of air. All samples were collected on millipore type AA filters. Radiation measurements were made with a Landsverk quartz fiber electrometer, beginning about one minute after sampling was completed, and continuing for 30 minutes. After subtraction of drift due to background, the number of divisions which the fiber had drifted were noted, doubled and recorded as a measure of the activity of the sample. The activity being measur-

ed is due almost entirely to alpha particles emitted by a mixture of short lived (about 40 minutes) isotopes, presumably natural in origin. No data has been obtained which indicate any correlation between activity measurements as made, and thermonuclear events. Reflectance measurements were made on all millipore filter samples with a home-made reflectance meter using white light.

Due to lack of personnel it was not possible to make a complete analysis of the data at this time. However a preliminary statistical treatment of these data revealed a correlation coefficient of $-.57$. This indicates a good relationship between radioactivity measurements and soiling power of air pollutants. Further exploration of this relationship could possibly lead to another means of estimating atmospheric thermal stability in the low levels and indirectly an index of pollution.

VISIBILITY MEASUREMENTS

In 1952 a Transmissometer was used to record light transmission through the atmosphere with good success. The transmissometer was operated during most of 1953 but the data were not analyzed in this report because of the lack of personnel.

PART IV

VEGETATION SURVEY IN DETROIT-WINDSOR AREA

A. GENERAL

Damage to vegetation is frequently ascribed to air pollutants; yet the literature on the subject is rather unsatisfactory because the effects, in general, are not expressible quantitatively, and prime attention has been given to particular situations such as may exist in the vicinity of a smelter or other source, where the injury is caused by one noxious gas and the plant species of value may be few. It is, however, recognized that plants vary widely in susceptibility to injury by atmospheric pollutants; some may develop damage symptoms under conditions that leave other species apparently unaffected. Varietal differences in susceptibility are well established for a few contaminants. The symptoms of injury produced by different pollutants are not identical, nor are they sharply characteristic. Although it is possible in some cases to infer the nature of the pollutants from the species affected and the type of injury observed, this is not a reliable or wholly dependable expedient. The injured tissues may sometimes be subjected to chemical analysis to provide supplementary information. It would be misleading, however, to imply that from the

examination of affected vegetation a confident decision could always be made as to the nature and amount of the injurious pollutant. Under some circumstances a guess may be made, but this is subject to serious uncertainties caused by the physiological age of the plant tissues and the climatic conditions that prevail during and shortly after the exposure.

The most obvious and dramatic symptoms of injury to vegetation consist of dead and necrotic areas in the foliage, which may be marginal, at the leaf tip, or in interveinal tissues. Exposures to a relatively high concentration of a pollutant for a short period is more likely to cause such injury than prolonged exposure to a low concentration. The latter may indeed not result in any generalized injury. In deciduous shrubs and trees, partial defoliation may occur following severe leaf injury. This, in turn, may cause premature developments of buds, or an abnormal habit of growth induced by injury to terminal shoots. Disease symptoms caused by pathogens in some species are not greatly dissimilar from presumptive pollution injury. Considerable caution has to be exercised in the case of apparent injury to trees in street plantings, because such an environment may be far from optimal for normal growth. In the latter part of the summer, particularly in the dry season, normal senescent changes in the vegetation may simulate some of the symptoms earlier ascribed to atmospheric pollution.

B. VEGETATION SURVEY

As a part of the general program of study of atmospheric pollution in the Detroit-Windsor area, it was decided that some attempt should be made to use vegetation to indicate the level of pollution that may be present. This might be done in one of two ways. Either uniform plantings could be established in areas known to be subjected to atmospheric pollution for comparison with similar plantings in clean areas, or the indigenous vegetation could be examined in polluted and clean areas provided the same plant material could be found in both.

The first alternative was initially preferred because by the device of including a sequence of plantings, material at the most sensitive stage would be present for several weeks. The species to be included were dependable annuals known to be injured by gases such as SO_2 , Cl or HF, namely buckwheat, chard, table beets, gladiolus and radish. It was not found feasible, however, to establish sufficient numbers of these plantings, partly because of insufficient time and inclement weather, but mainly because suitable sites under the control of the City of Detroit were not available. Of the five available, three were in areas considered to be clean.

Accordingly, it was decided to make a survey of indigenous vegetation, particularly in the vicinity of some known probable sources of pollutants in order to

determine the susceptible species and the nature and extent of injury. In the Detroit area small garden plots are to be found in almost every street and in the immediate vicinity of almost all heavy industrial plants. They are absent only in the downtown area. This circumstance makes more valuable a vegetation survey because in general the same species are to be found in these garden plots. Cemeteries were also included in the survey because of the ornamental species widely planted in such places. None of the personnel participating in the survey had previous experience in evaluating plant injury caused by air pollutants, so that the observations that were made were also of educational value to those involved.

C. OBSERVATIONS

First, it should be said that unequivocal symptoms of injury to vegetation were only found in close proximity to presumptive sources of relatively large quantities of air pollutants, and that in some locations in the shadow of industrial plants the vegetation appeared wholly normal. In so-called "dirty" areas, there was no indication of a background of pollution causing general and widespread repression of growth or foliar injury at a threshold level. It is true, of course, that there are no "unexposed" plants in polluted areas, but acquaintance with the normal plant leads to the above conclusion.

The location of the tissue damage to injured plants was such as to suggest that most cases of injury were related to specific incidents, probably of relatively short duration. Such a conclusion could not be made with all species because leaves of different age are not equally sensitive to injury. Moreover, the symptoms of injury are permanent; an injured leaf re-exposed does not develop additional symptoms. The most striking, serious and perhaps extensive area of injury seen by the survey group was in Wyandotte in the immediate vicinity of a chemical plant. The visit to this area was made several days after a large scale gas emission had occurred. This pollution was reported at the time to have been so heavy that discomfort and alarm had been experienced by the residents of the area. Such emissions had apparently occurred in the same area in the past, with the result that there were signs of greater abnormality in the trees than observed elsewhere.

In the following paragraphs are brief notes on species observed to be abnormal because of air pollution in the various areas studied. It is to be understood that in most areas the observations were not confined to one garden or plot, and that the survey group generally took a wide enough swing to ascertain whether any injury noted was local or more generalized. Toward the latter part of the summer it became increasingly difficult to

distinguish between suspected pollution damage and other effects, such as leaf scorch and leaf drop which can occur in all areas.

18 June

1. W. Patton Park - Small garden plot at road intersection. Mixed vegetables. Table beets possibly affected. Some bronzing and separation of epidermis. Tomatoes normal.
2. West Wyoming - Garden plots. Table beets possibly affected. Onion leaf tip burn. Iris, zinnia, strawberries and other vegetables normal.
3. Wyoming, south of Lapeer St. - Table beets possibly affected. Radishes exhibited some marginal bleaching and in interveinal areas. Onion leaf tip burn. Other vegetables normal.
4. Cemetery. E. side of Woodmere by Chamberlain. - Lilies of the Valley, widely planted, all exhibited tip burn, mostly fairly severe. Plantain Lily (Hosta) similarly affected. Older leaves of Iris showed tip burn. Variegated Hosta was not injured, nor were a number of summer annuals recently set out. The indications were that the injury had occurred some weeks earlier, SO_2 being the probable cause. Annual and herbaceous plants seemed normal.
5. Near oil refinery; fuel tanks quite close. - Two small garden plots were found to be entirely normal.

No epinasty was visible in tomatoes as might have been expected if lower hydro-carbons were present in sufficient concentrations to cause it.

6. Adjacent to fertilizer plant - In the past, this plant had been a source of HF. Windows in vicinity were highly etched, and all house paint was in poor condition. Flower gardens and vegetable plots in the adjacent 3 or 4 blocks were examined. Lily of the Valley and Hosta showed severe tip burn. Lupin leaves were curled. Some damage symptoms on growing point and young leaves on a Ribes bush. This was near to an alley in which rubbish is burned in incinerators. Most species in this area looked normal, indeed one of the best vegetable gardens seen anywhere was only 150 yards from the fertilizer plant.

2 July

7. Junction of Biddle and Marshall - A heavy gas emission was known to have occurred several days prior to this visit. Injury was clearly visible for several blocks downwind of the presumptive source. In the block nearest the source, dramatic symptoms were found on most plants. The following species were severely affected: Lily of the Valley - tip burn; Iris - tip burn; Rose - leaves had terminal and peripheral burn, purplish pigmentation adjacent to the dead tissue; Convolvulus minor - leaves developed eroded areas; Peony - tip burn; Cabbage - irregular eroded lesions

on leaves: Rhubarb - very severe injury to interveinal tissues; Onion - leaf tip or distal end of leaf killed; Balsam - narrow marginal burn; Hollyhock - severe marginal burn so that leaves became hexagonal; Gladiolus - tip burn about 1" in length; Tomato - tip burn on older leaves, some epinasty and incurvature of lower leaves; Strawberry - marginal injury to leaves; Radish - interveinal tissue bleached; Campanula - plants killed; Phlox - lower leaves exhibited terminal and marginal burn; Petunia - severe general injury; Canna - interveinal lesions; Ash - extensively defoliated; Trumpet vine - peripheral leaf injury; Box Elder - extensive marginal leaf burn, some defoliation; Pear and Apple - not much injury other than marginal leaf burn; Catalpa - 25 percent defoliated, remaining irregularly spotted or eroded, some marginal burn; Forsythia - leaf tips burned, margins unaffected. Apparently undamaged were the following: Zinnia, Chrysanthemum, Dahlia, Privet, Rose of Sharon, Mulberry, Hydrangea.

8. Approximately 100 yards south of Position 7 - In general, similar symptoms were apparent but the severity was noticeably less.
9. Approximately 200 yards south of Position 7 - Further diminution in severity of responses was evident, though injury would still be said to be substantial by comparison with observations made elsewhere.

10. Approximately 300 yards south of Position 7 - At this distance, not all responsive species had developed any symptoms of injury. Many, in fact, were normal or nearly so. The following were noted as exhibiting some response: Lily of the Valley, Rhubarb, Strawberry, Radish, Onion. Both Tomato and Petunia were normal. However, some Box Elder trees were partially defoliated and differed little in appearance from one seen in the zone nearest the presumptive source.

16 July

1. Veterans Memorial Building - Other than a slight marginal leaf burn on a planting of Crataegus trees, there was no evidence of any damage among the ornamental plantings around the building. In general, however, the plants at this location showed considerable accumulation of particulate matter on the leaves.
2. Immediate environs of a chemical company - Examination of this location was requested, since it was known that as a result of an operational change, the plant was temporarily using lower stacks rather than the high one for emission of its wastes. Although a slight tip burn was noted on the plantain and tiger lilies, there was little evidence of other vegetational damage. This was true even in some areas

around the plant where sulfurous odors were definitely noticeable.

3. Belle Isle - This was not considered close enough to pollution sources to expect vegetational damage, and none was observed. The island thus served as a control area.
4. Area of home garden plots approximately $\frac{1}{2}$ mile east of a power plant - None of the plants in these gardens showed evidence of air pollution damage.

6 August

1. Junction of Biddle and Marshall and environs - Although in general those species which had shown extensive damage at the time of the earlier visit had recovered to some extent, recovery was far from complete. The rhubarb, for example, still showed extensive damage of the interveinal leaf tissues. One ash tree which had been severely defoliated had put out new growth.
2. Trenton - In the village proper, the vegetation appeared normal. The area around a chemical plant was also surveyed. A buckwheat planting across the road from the plant showed marginal leaf burn. The ornamental shrubs surrounding the county building immediately north of the chemical plant showed extensive damage. Privet and viburnum were partially defoliated and considerable dead wood was in evidence.

Elms exhibited some defoliation and a whitish deposit was apparent on the side of the tree trunks nearest the chemical plant.

3. Grosse Ile - Several stops in the island, including one at a commercial nursery, did not reveal any damage ascribable to air pollution.
4. Ecorse, in the vicinity of steel plant - Vegetation appeared normal. Blast furnaces are located approximately $\frac{1}{4}$ to $\frac{1}{2}$ mile from the fence surrounding the plant so that there was no opportunity to observe vegetation in close proximity to the furnaces.

D. CONCLUSIONS

The following conclusions are arrived at somewhat diffidently in view of the inexperience of the observers, but would appear to be supported by the survey.

1. Unequivocal symptoms of injury to vegetation were found only in close proximity to presumptive sources of atmospheric pollutants, and were probably related to specific periodic emissions, perhaps of short duration.
2. Much of the vegetation in the Detroit area, even in areas that are predominantly industrial, appeared normal in early and mid summer. Later in the season it became difficult to distinguish between suspected

pollution injury and the normal senescent changes that occur in a dry season.

3. There was no clear indication of a background level of pollution in the industrial areas of Detroit sufficient to cause generalized growth repression or foliar injury.
4. Although certain pollutants undoubtedly cause different degrees of injury to vegetation, the observations made this summer were not sufficient to indicate that confident diagnoses of the gases involved could be made by identifying characteristic symptoms in the species affected.

E. RECOMMENDATIONS

1. Should it be considered desirable to repeat or extend the survey in another season, more intensive observations should be made in May and June while much of the foliage is in a sensitive or responsive condition. Particular plants or plantings in the vicinity of suspected sources might be observed at frequent intervals to attempt to relate injury to known emissions.
2. With the cooperation of industry, indicator plants in pots might be placed at various distances from a stack or blow-off from which contaminants are emitted, and these picked up after exposure, for a limited period, and transferred to a clean environment for observation of subsequent growth.

PART V

R E F E R E N C E S

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